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Since structural dimensions of knowledge and learner contribute to preferred message structure, an understanding of structural relationships can aid in the more effective design of instructional messages. Five studies were conducted to explore these relationships. Knowledge structure was defined as the iconic representation of the body of knowledge in question, learner structure as those stable response tendencies predictive of learner behavior, and message structure as the temporal order in which elements within iconic structures are presented to learners. Graduate education students were asked to respond to a range of iconic knowledge structures. Judgments, problem-solving, and verbal learning were explored. The distribution of response frequencies suggested that learning can be facilitated or retarded according to the structure of the message and that different types of learning may call for different types of message structure. Findings on the role of individual differences were inconclusive. Preferred temporal order of message elements in an iconic knowledge structure was found to be dependent on the kind of structure in question rather than on the content of the message. (Chi-square analysis, $p<.001$). (LS)

# FINAL REPORT

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# The Temporal Dimension of Message Structure

March 1968

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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# MESSAGE DESIGN: THE TEMPORAL DIMENSION OF MESSAGE STRUCTURE

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M.L.F.

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## SUMMARY


The purpose of this study was to explore the general topic of structure in the teaching-learning process. Three aspects of structure were studied: knowledge structure, message structure, and learner structure. An attempt was made to explicate critical dimensions of each and to discover congruities between them.

The most difficult conceptual problem was that of operationally defining knowledge structure. While several authors have categorized the major ways of knowing as exemplified by the academic disciplines, few of such gross distinctions proved useful at the level of a single concept or a particular unit of instruction that might be employed for experimental purposes. As a consequence a body of knowledge was conceived of as a set of elements linked together by a substantive structure, which structure is described by the kinds of relationships between the elements. A survey of the types of relationships found in a sample of textbooks yielded four generic classes: causal relationships, magnitude relationships, time relationships, and hierarchical relationships. The typical modes by which these relationships have been iconically represented were abstracted and classified, generating a series of iconic knowledge structure types described as linear, cyclical, stellar, and hierarchical.

Knowledge structure was operationally defined according to the set of iconic structure types. Message structure was defined by the temporal order in which elements within the structures were presented to learners. Learner structure was defined by several cognitive measures thought to be relevant to this problem area.

Several cognitive measures were tested in the search for a operational definition of learner structure. The Closure Speed and Closure Flexibility tests were employed as possible predictors of responses to the figures that were defined as knowledge structures. The Siegel and Siegel Test of Educational Set was employed as a possible predictor of fact-seeking vs. concept-seeking tendencies. Measures of intelligence, the Similarities Subtest of the Wechsler and the Wonderlic, were employed as possible correlates of behavior on the verbal learning tasks.

Following the conceptual analysis, a series of five empirical studies was conducted relative to several pertinent questions. The pervasive research question was: Given a certain organized body of knowledge (knowledge structure), and given learners with certain cognitive styles and predispositions (learner structure), what kinds of messages and message materials (message structure) would constitute the optimum design for learning? Following are some of the more specific questions pursued. What substantive relationship classes are associated by learners with what iconic knowledge structure? What temporal order strategy is preferred for each iconic knowledge structure? To what extent are iconic knowledge structures used by learners in problem solving tasks? What is the effect of temporal order strategies on

recall of elements in knowledge structures? How do learner structure types and learning task constraints relate to the above?

The methods employed varied widely across the five studies. The 11 experimental tasks varied from individual judgments, to verbal learning, to problem solving. Analyses varied from an inspection of frequencies through several nonparametric statistics to analysis of variance. The strategy in general was to give each of the three main variables (knowledge structure, message structure, learner structure) an initial investigation (Studies 1 to 3) followed by several multiple-variable investigations (Studies 4 and 5).

The report relates the studies conceptually, procedurally, and empirically to a diversity of related research literature. With reference to both this study and the other studies reviewed, the following general conclusion was reached:

Conclusion #1 -- The general conclusion that learning can predictably be facilitated or retarded according to the structure of the message (stimulus) has been repeatedly demonstrated across several types of learning (paired associate, serial, concept) and with several types of message vehicles (verbal, figural, pictorial). However, the specific findings indicate that particular types of learning may be differentially associated with particular types of message structure. Further, the strength of the association is multiply determined by interacting factors such as knowledge structure, learner structure, and task constraints.

Specific to this study were several more specific and tentative conclusions:

Conclusion #2 -- Graduate students in education perceive certain iconic knowledge structures as differentially depicting the following types of substantive relationships: magnitude relationships, temporal relationships, causal relationships, and hierarchical relationships.

Conclusion #3 -- The above perceptions of relationships are shown to be selectively sensitive to changes in orientation of the structures and to changes in attributes such as the addition or deletion of arrows.

Conclusion #4 -- The characteristics of the perceived relationships between substantive elements vary systematically with the position of the elements within the structures.

Conclusion #5 -- Judgments by graduate education students of the optimum temporal order in which to encounter the substantive elements in an iconic knowledge structure exhibit several patterns. These patterns or learner-strategies are to a degree characteristic of the different iconic structures. However:

A. Some individuals tend to be consistent in their preferences for similar temporal order patterns across different knowledge structures.

B. When motivational constraints are applied to this judgmental task, individuals who score high on the Siegel Test of Educational Set tend to modify their judgments more than individuals scoring low, and the direction of this change is from logically "poor" strategies to logically "good" strategies.

Conclusion #6 -- Scores on various standard test instruments frequently are not found to be associated with judgments or preferences on various experimental tasks. However, several exceptions were observed:

A. Students scoring high on the Siegel Test of Educational Set exhibited a strong preference for certain patterns of encounter with a hierarchical structure while students scoring low on the test responded in an undifferentiated manner.

B. Scores on a relationship learning task were significantly and positively correlated with scores on Closure Speed and Closure Flexibility Tests.

C. Scores on a verbal hierarchy learning task were significantly and positively correlated with scores on Closure Flexibility and the Wonderlic Personnel Test.

D. High Siegel scoring subjects changed patterns of responding to different iconic knowledge structures and different task constraints more frequently than did low Siegel subjects.

Conclusion #7 -- Students exhibited a consistent tendency to prefer or seek to encounter first the more superordinate elements in a hierarchical knowledge structure. Further, regardless of the order in which they were presented such elements in a learning task, they tended to recall more superordinate elements than subordinate. Several alternative explanations of this finding are offered.

Recommendations -- It was recommended that additional work be done in relation to the questions which follow. Some questions tend more toward the applied or developmental while others tend more toward research or theory.

1. Producers of instructional materials already employ such iconic structures as time lines, number lines, Venn diagrams, structural formulae, taxonomic structures, flow charts, process cycles, etc. Can more of such devices be used and evaluated in instructional materials and methods?

2. In what subject areas might the iconic structuring of concepts bring order to the message designer's task of selecting and sequencing the constituent elements of messages (films, textbooks, programmed instruction, television)?

3. To what extent can the efficacy of iconic knowledge structures

be increased by the innovative design of novel structures and models or the modification of known structures?

4. In what subject areas or for what kinds of objectives might iconic structures be effective in instruction, serving to aid comprehension and memory?

5. Is there a relation between the tendency to use structural aids in problem solving and the characteristics of learners and of problem situations?

6. Are certain iconic structures instrumental in facilitating transfer of learning?

7. Can iconic models and structures objectify the study of image thinking in the same way that sentences of appropriate types have objectified the study of verbal thinking (classical logic)?

8. When are the observed associations learned between iconic knowledge structures and substantive relationships: magnitude, temporal, causal, hierarchical? Can they be formally taught and at what age?

9. In what additional ways might the theoretical construct of structure serve to generate productive analogies and models of knowledge, messages, learners, and the interrelations between?

10. What kinds of iconic aids to thinking do learners generate in complex situations?

# CHAPTER I

# INTRODUCTION

This study, or series of studies, was proposed as "an initial exploration of the possible relationships between the structural dimensions of knowledge, message, and learner."

Three aspects of the above proposal statement are pertinent to this introductory statement of the final report. First, the proposed variables, "knowledge, message, and learner," were seen primarily from the practical viewpoint of a message designer. That is to say, given a certain organized body of knowledge (subject matter, concepts), and given learners with certain cognitive styles and predispositions, what kinds of messages and message materials would constitute the optimum design for learning? This question characterizes the applied orientation of the study.

Second, "the possible relations between the structural dimensions," was the aspect of the proposal statement which importantly delimited the study and gave it direction. It acknowledges the fact that the concept of "structure" has been useful in the separate analysis and study of each of the variables. (See sections in the Background of the Problem on knowledge structure, message structure, and learner structure.) It further suggests the theoretical interest of the study in "structure" as a unifying construct.

Third, "an initial exploration," suggests the pilot-study character of the investigation. The five studies herein reported are exploratory, but as a series they also reflect increasing conceptual and methodological refinement.

## Problem

As already indicated, the problem of this study, when stated as a general research question, was: Given a certain organized body of knowledge (knowledge structure), and given learners with certain cognitive styles and predispositions (learner structure), what kinds of messages and message materials (message structure) would constitute the optimum design for learning? The companion theoretical question was: Might some conception of "structure" provide a useful theoretical framework within which to analyze and study the research question?

The above research question was variously and more explicitly stated for each of the five studies that evolved. The eventual 17 specific research questions are presented in Chapters II to VI of this report in the Purpose sections of the respective studies.

## Definitions and Limitations

The three variables were operationally defined in somewhat different ways from study to study. However, they were delimited in general to the following:

Structure -- An interrelation of parts as dominated by the general character of the whole (Webster).

Structure of knowledge -- The relationship between substantive elements in a concept. The several logical relationships studied included part-whole and before-after. For example, "composer" and "painter" can be seen to bear a part-whole relationship to "The Arts."

Such relationships or structures of knowledge were conceived and represented, not as mathematical equations nor as logical propositions, but as logical pictures (16), informational structures (2), or iconic knowledge structures. An example would be the hierarchical diagram (Figure 13, page 59) typically used to represent superordinate-subordinate relationships of many kinds, such as between composer, painter, and The Arts; or between plants, animals, and living things; or between the constituent parts of an organization and the whole.

Iconic knowledge structure* -- A representation of the relationships between substantive elements, which representation is non-arbitrary, i.e., it in some way "resembles" the relationship.

Structure of the learner -- Standard cognitive instruments which measured somewhat stable response tendencies and which were presumed to be predictive of learner behavior relative to various experimental tasks, tasks typically requiring visual form perception and/or verbal learning.

Structure of the message -- Primarily the temporal structure of messages, though spatial structure factors were present in some tasks. Typically, the temporal order of presentation to a learner of the constituent elements in a concept.

The three variables are more fully explicated with reference to the literature in the Background of the Problem section and in Chapter VII, and with reference to the experimental tasks for each study, Chapters II to VI.

The strategy of this study, judged to be compatible with its exploratory character was, first, to do a series of small-scale probing

*The distinction between sign and sign vehicle, Knowlton (16), was not made in this report. An iconic knowledge structure as a physical object would be a sign vehicle, while as a response predisposition or as something on which meaning is conferred by an interpreter the iconic knowledge structure would be a sign.

studies instead of one large-scale but premature study. Second, the strategy was to do an introductory study of each variable (Studies 1-3) followed by more complex designs involving combinations of variables (Studies 4 and 5). Third, the series was to increase in rigor as it progressed. For example, subjects in Study 1 were asked to select the temporal order in which they would prefer to receive message elements, while in Study 5 two defined temporal orders of encounter were the independent variables for a memory task. Thus, data varied from nominal to interval and the statistical treatments varied accordingly.

## Justification

This study was directed toward the problems of the designer of instructional messages, i.e., anyone responsible for arranging the conditions of learning, be he a teacher, curriculum supervisor, programmer, instructional film or TV director, text or curriculum writer. However, the research approach to those problems was intended to be at a level sufficiently basic to have implications for a variety of types of subject matter, types of learners, and types of messages and media.

With reference to the message variables the study was an attempt to investigate applied problems but at a research level rather than an evaluation level. Implicit was the assumption that message variables were a larger source of variance in the teaching-learning process than were media-specific variables, and hence were more important to understand and control for both the researcher and the practitioner in the field.

With reference to the knowledge structure variables, the justification of the study was seen to be its pertinence to current problems of curriculum revision and instructional system design. Much has been said and written to the effect that in both content and method the teaching of science, for example, must bear some isomorphic relation to scientific inquiry as it is understood and practiced by today's scientists. However, the attempts to translate such principles into instructional materials and policy have been far less frequent. How can the structure of a subject be represented most effectively in messages intended to teach it?

The number of facts presently a part of each discipline is beyond the possibility of coverage in the curriculum and is still increasing at an accelerated rate. Selection is an obvious answer, but is it a sufficient one? Bruner says, "Perhaps the most basic thing that can be said about human memory, after a century of intensive research, is that unless detail is placed into a structured pattern, it is rapidly forgotten." (4:24) What kinds of message structurings might facilitate the structuring processes in memory?

Bruner further states, "There are certain orders of presentation of materials and ideas in any subject that are more likely than others to

lead the student to the main idea." (4:82) But what kinds of orders of presentation are better suited for what kinds of subject matter and what kinds of learners? This study was directed toward the temporal order variable in message design.

With reference to the learner structure variable, it is a truism that the characteristics of instruction should not be determined independently from the characteristics of the learner. The justification for including such a variable in this study is not simply that it is important or that it hasn't been adequately researched or that technologically the individualization of instruction is now feasible. Rather, the growing body of studies dealing with what is called cognitive style and cognitive structure show promise for bringing some order to the complex domain of individual differences, thereby increasing the likelihood that further regularities can be found between learner characteristics and message characteristics.

In sum, the primary justification for the study is that it deals with certain current and critical issues in education and attempts to do so in a way useful to both educational researchers and practitioners.

## Background of the Problem

In the following review of literature a section is devoted to each of the three variables. Following those three sections is a final section covering related studies reported during or since completion of this study.

Structure of knowledge. Though the characteristics and structure of knowledge have long been the objects of philosophical discourse, within the last 10 years there has been new interest on the part of educators and subject matter authorities. This interest has been due in part to the anticipation that the structures of knowledge would reveal the essential constituents and relationships in a discipline, which essentials would be useful guides to the selection and organization of curriculum content. The concept of structure has been applied to knowledge at different levels. As Schwab observes:

> "First there is the problem of the organization of the disciplines: how many there are; what they are; and how they relate to one another.
>
> Second, there is the problem of the substantive conceptual structures used by each discipline.
>
> Third, there is the problem of the syntax of each discipline: what its canons of evidence and proof are and how well they can be applied." (31:14)

Writers such as Phenix (25) and Tykociner (41) have constructed schemata at the first level, suggesting the organization and interrelationships of whole disciplines.

A much more manageable level for this study was the second, that of the substantive conceptual structures. Only at this level could knowledge and structure be made operational for a study of this magnitude. If substantive concept structures were to be the objects of study, a category set for them was needed. The most frequent syntactical categories for concepts found in the literature were: conjunctive, disjunctive, and relational. The latter, the relational concept, was chosen for investigation because it appeared to mesh most productively with the iconic type of structural representation being considered. (More about iconic structures shortly.) Also, Carroll (6) has observed that many of the concepts encountered in school subjects are defined by the relations among environmental attributes rather than by their presence or absence, that is to say, by relational concepts rather than by conjunctive or disjunctive concepts. It is the latter two types of concepts that have typically been selected by psychologists for the study of concept learning.

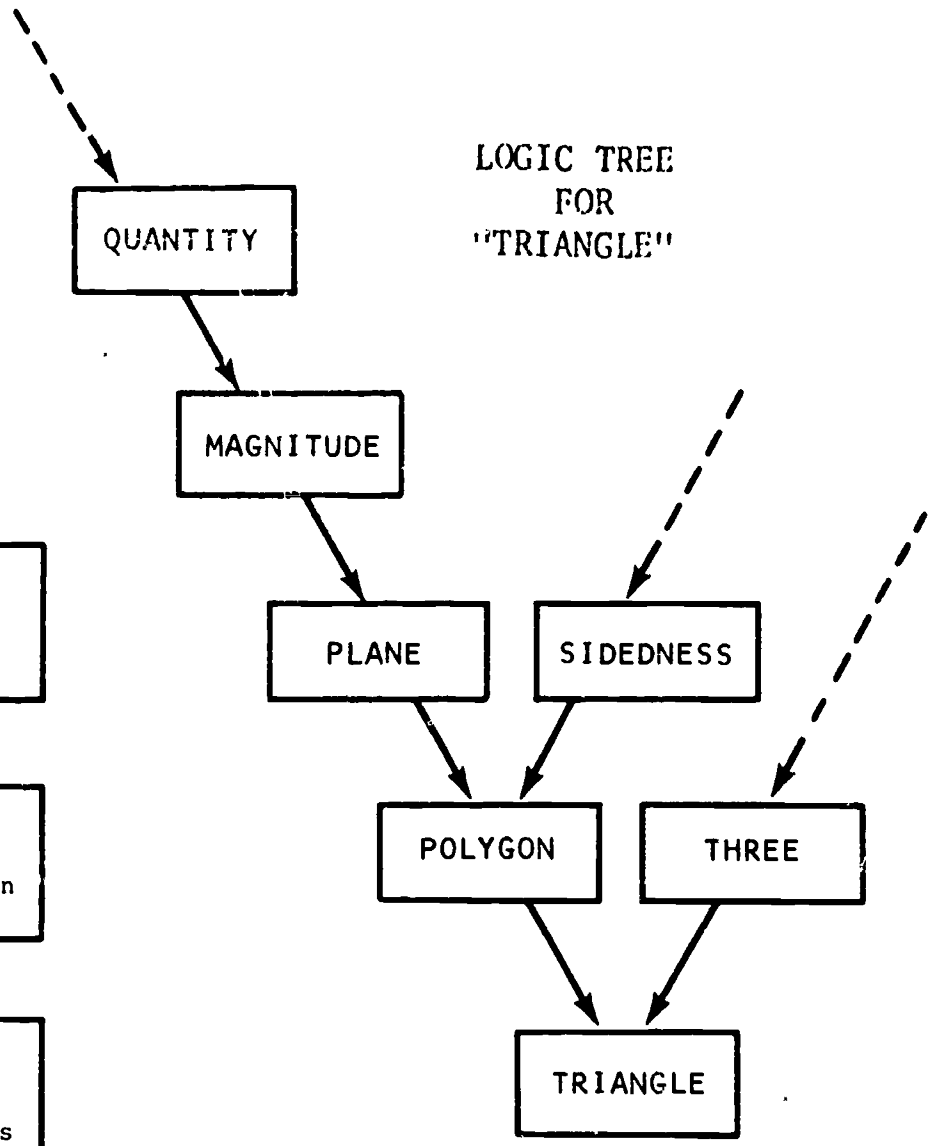
The next requirement was for a category set of relational concepts. This was derived from an analysis of a convenience sample of textbooks in four subject areas. This analysis yielded four generic classes of relationships: causal relationships, magnitude relationships, temporal relationships, and hierarchical relationships.

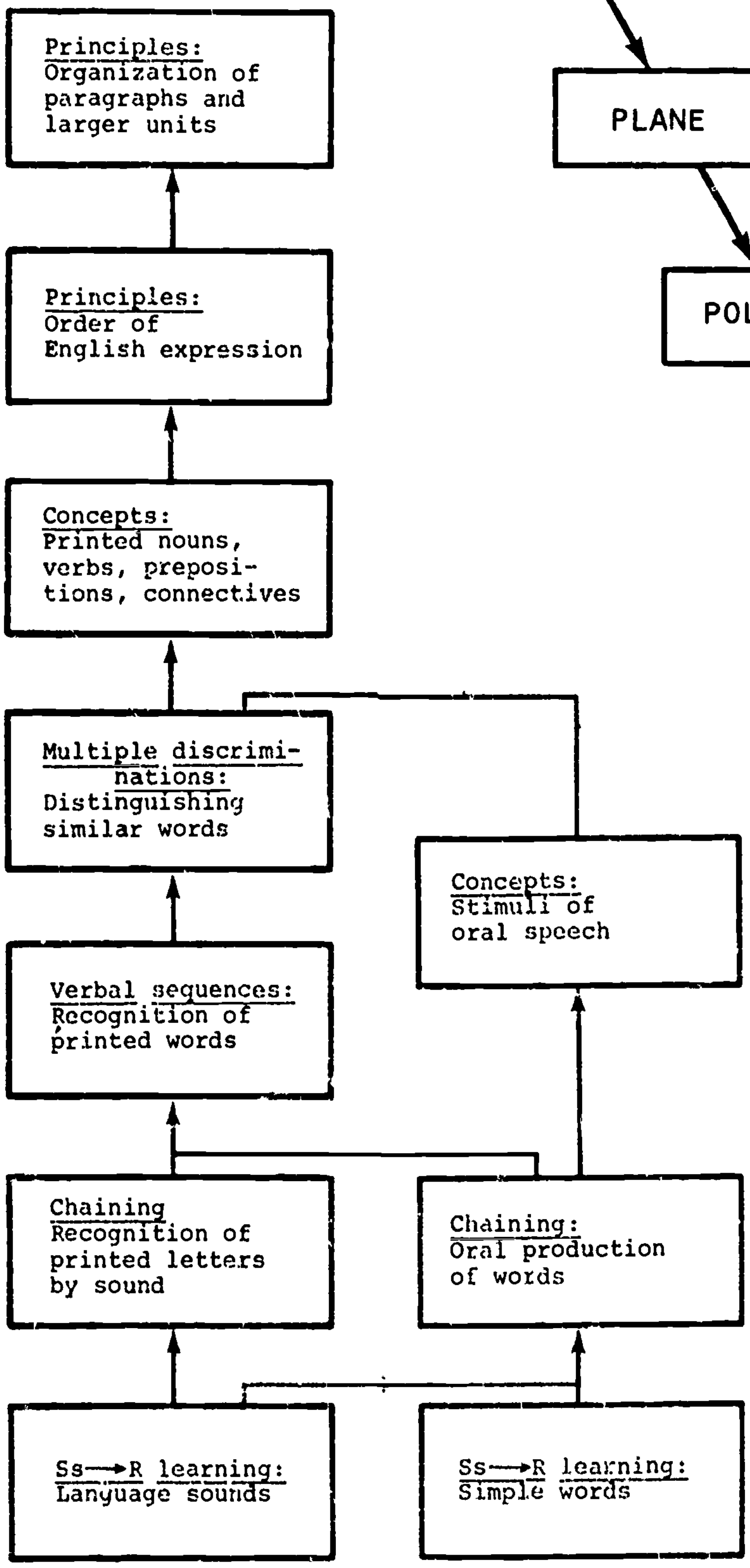
It was necessary to establish some form for representing the concepts studied. Smith (34) has been a proponent of the use of logical operations to structure classroom discourse, but this seemed too limiting for the purposes of this study. McClellen has persuasively proposed, "that we should keep our minds open to the possibility (it seems to me a foregone conclusion) that rationality and intelligibility may take many forms, some radically different from technical logic, that the process of teaching and learning these forms may present radically different problems for teachers." (21:158)

The equation represents another type of depiction of relationship. Johnson (15), for example, in studying subject matter structure employed equations such as: force = mass x acceleration and acceleration = velocity/time. These are powerful structures, but again somewhat limited in applicability.

The search for other structures or forms that rationality might take strayed from linguistic and mathematical forms to others such as graphic or iconic. Interesting examples found were a "logic tree" for the concept "triangle," Hickey (11), and the representation of a learning structure for reading, Gagné (9), Figure 1. This discovery was reinforced by the recent observation of Harré that, "Postlinguistic philosophy is characterized by the insight that language is not the only vehicle of thought. . . . Just as propositions have their objective counterpart in sentences, which can be serious objects of study, carrying

LOGIC TREE FOR "TRIANGLE"




LEARNING STRUCTURE FOR READING (from The Conditions of Learning, R. M. Gagne, Copyright (c) 1965 and reproduced by permission of Holt, Rinehart and Winston, Inc.)

Figure 1. Logic Tree for the Concept of "Triangle," Hickey (11), and Learning Structure for Skills in Reading, Gagné (9)

propositions independent of individual thinkers, so models and pictures can perform the same task of objectivization for image thinking." (10: 13, 14) It should be noted here that the study of "mental images" is now regaining respectability as attested by the recent studies reported in the last section of this review and in Chapter VII.

It was decided that two of the characteristics of logical form would be required of the iconic structures being selected--they must be "empty" and they must stand for a relationship between constituent elements. To be "empty" the structures must be suitable for more than one set of constituent elements. To stand for a relationship the structures must restrict the character of constituent elements and their location within the structure.

It was speculated that such structures might, on further study, come to be considered one of the forms of logical thought. Further, such structures might on analysis and empirical investigation be shown to be generic in the sense that they would facilitate initial learning of the constituent elements of a concept, would facilitate delayed recall of the concept, and would facilitate transfer.

The search in textbooks and elsewhere for such visual-iconic structures yielded a surprisingly large and diverse number. See examples in Figure 2. They were reduced to several distinguishable groups of which the examples in Figure 3, page 21, can be taken as typical. The substantive structures in Figure 2 can be seen to suggest types of relationships between the constituent elements. Graphic types are also observable such as linear, circular, convergent or divergent, parallel.

Such structural representations of knowledge not only showed constituent elements in a relationship, but they also permitted analysis, categorization, and manipulation. For example, solution of the problem of identifying possible experimental conditions (orders of presentation of elements) was facilitated by the iconic representation of the concept.

It remained to be demonstrated empirically that such iconic structures were useful to this study or to subsequent research and practice.

Structure of messages. The reviews that follow have been selected primarily to suggest the pervasiveness of message structure variables across diverse media. None of these studies employed the medium used most frequently in the present study, the overhead projector and transparency. The reasoning, as suggested earlier, is that the variable under study (temporal order of presentation) is a message variable and as such is to a considerable degree independent of media or, at least, is apt to be a larger source of variance in learning than are media.

A study of public speaking by Thistlethwaite, deHaan and Kamenetsky (36) found that a speech with a well-defined organization (with sentences of introduction, transition, and recapitulation, but no new information) led to greater comprehension than one without. Differences were significant.

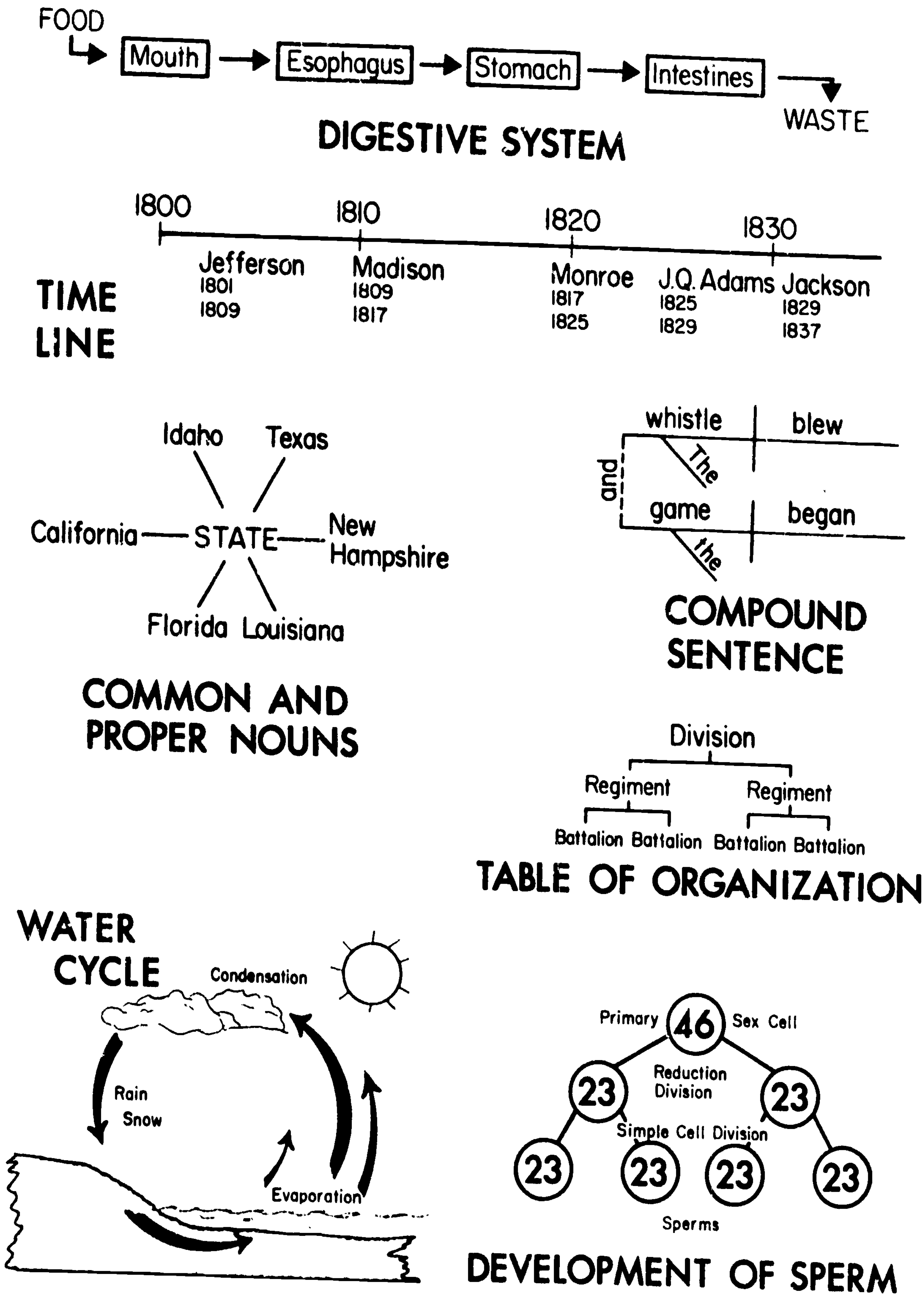



Figure 2. Examples of Iconic Knowledge Structures Found in Sample of Textbooks

A study of instructional film by Northrop (22) found that the insertion of titles and subheadings for the purpose of making more prominent the organizational outline of a film increased learning if the film was not inherently well organized, i.e., if it had a discrete-item treatment rather than a logical or a chronological development. The significant differences in learning were associated with the lower half of the group with respect to IQ.

Four studies of programed instruction, as reported by Schramm (30), compared programs having logically sequenced items with programs having randomly ordered items, the programs being otherwise the same. Two of the studies found no significant differences and two found differences favoring logically structured programs.

A study by Hickey (11) used programed material to deal with some of the message-to-knowledge relationships implied earlier in this report. He states the problem as one of fitting a multi-dimensional knowledge space to a one-dimensional teaching space. The limited dimensionality of the teaching space is due to the limited capacity of the learner to cope with more than one dimension of a message at a time. For a knowledge structure Hickey used a logic tree for the concept, Gross National Product (similar to that shown for the concept Triangle in Figure 1). He designed twelve self-instructional programs to represent possible teaching strategies for temporal ordering of the several subconcepts given within the logic tree. A preliminary study using these twelve program versions with 132 subjects yielded significant differential effects on learning as a function of subconcept sequence. These differences occurred for two criteria, time to complete and score on a transfer test, but not on a third criterion, error rate.

In an experiment by Allen and Cooney (1), linear and nonlinear film formats (structures) were compared. In the linear film the images were sequentially ordered (temporal structure) so that each appeared in isolation and was replaced by the next image as is characteristic of the film medium. In the nonlinear film the same images appeared in the same order but accumulated to fill the screen, or were replaced, until a sequence was complete. This gave the structure both a spatial and temporal dimension.

There was additionally a content factor involving different pictorial and verbal elements, being for the factual version "concrete" visuals (photos) and descriptive narration, while being for the conceptual version "abstract" visuals (graphic symbols) and explanatory narration.

For the sixth grade subjects receiving the factual treatment the linear structure yielded the better scores, while for those receiving the factual-conceptual treatment the nonlinear structure yielded better scores. The eighth grade subjects learned the concept equally well in any version, but the girls retained it better in the nonlinear format and the boys retained it better in the linear format.

Noteworthy are two studies by Cobin and McIntyre (7) which explored analogous relationships between message structure and television presentation structure. The first dealt with a lecture, the structure of which was accentuated by the video presentation, i.e., the more important the part of the lecture being covered the closer the camera was to the lecturer. Two methods were tried for reinforcing the points of change in the lecture--dollying in (gradually moving the camera closer) and switching (abruptly "cutting" or jumping to a new camera position). After the lecture, students were asked to organize the concepts in outline form. The outlines were scored for errors in sequence and subordination. No significant differences were found between the two methods of accentuating the message structure. However, since there was no control group, the basic idea of analogous structuring between message and video presentation was not itself tested.

The other study by the same authors (7) was of a lesson on metrical analysis for which an analogous metrical switching of camera viewpoint was experimentally introduced. Seventy-five college students, randomly assigned to the two treatments, were shown the lessons and given five metrical analysis tasks to perform. Chi-square analysis revealed a significant difference favoring the rhythmic (metrical) switching over the non-rhythmic switching. However, a replication of this study with sixty-five students failed to yield significant differences.

Lumsdaine's critical review of audiovisual literature (18) includes two sections on organizational and sequential factors which are remindful of the fact that other variables are determinative of temporal message structures. Among these are the factors of fatigue and the distribution of practice and effort.

No review of sequential factors would be adequate without recognition of the contributions of Hovland and others (12) to the understanding of the effects of primacy in persuasive messages.

This brief review of literature on message structure has attempted to demonstrate the pervasiveness of the concept of structure across diverse media and to note the suggestive, though scant, beginnings of research relating the structure of messages to the structures of knowledge and learner.

Learner structure. As defined earlier, the locus of this variable was with standard cognitive measures judged to measure somewhat stable response predispositions which might be predictive of learner performance on the types of tasks characteristic of this study. Interest was thus on perceptual organization and verbal learning, i.e., at the interface between perception and learning where theoretical controversy continues between cognitive and S-R persuasions and where an increasing amount of investigation is occurring. The review that follows will be largely restricted to the types of tasks and measures used in this study.

Because of the verbal learning aspect of some of the tasks in Studies 4 and 5, some standard measure of intelligence such as the

Wechsler (Similarities Subtest) or the Wonderlic was judged to be appropriate. The Similarities Subtest of the Wechsler has been shown to correlate .72 with the verbal comprehension subtest and .73 with the rest of the test. Correlations for the Similarities Subtest were among the highest obtained either with other subtests of the Wechsler or with the total score. (42) The Wonderlic Personnel Test correlates .81 to .87 with the Otis Self-Administering Test of Mental Ability, Higher Examination, but no correlation figures were indicated for verbal aptitude measures. (45)

Attempts to measure other aspects of cognitive structure were limited to three instruments: Educational Set Scale by Siegel and Siegel (32), Closure Speed Test, and Closure Flexibility Test (Concealed Figures) by Thurstone and Jeffrey (39) (38). The Educational Set Scale was designed to distinguish subjects with a factual set from those with a conceptual set. Items are triads such as the following:

41. The causes of earthquakes.
42. The names of the world's major oceans.
43. The distinction between anthracite and bituminous coal.

Subjects were to assume they were enrolled in a course dealing with such topics and were to rank them in the order of their interest from most to least. There are 31 such triads on the test from across six subject areas. Siegel and Siegel (32) predicted that conceptually set subjects would be more likely than factually set subjects to learn both factual and conceptual content. A study by the authors yielded a significant main effect supporting this prediction. It was anticipated that in the present study high conceptual set subjects would prefer and would perform better on tasks wherein factual elements were encountered in a conceptual structure.

The Closure Speed Test is a measure of the speed with which a subject can integrate apparently unrelated parts into a meaningful whole. The test appears to differentiate subjects in the area of temperament, high scorers being identified as outgoing, reactive, other-oriented, artistic rather than logical or theoretical. (39)

The Closure Flexibility Test (Concealed Figures) is a measure of the ability to hold a configuration in mind despite distraction. It requires the capacity to see a given figure which is embedded in a larger and more complex figure. The items are a refinement of the original Gottschaldt Figures. Scores have in several studies been found to correlate .59 to .64 with analytical and reasoning factors. Subjects scoring high appear to consider themselves socially retiring and having theoretical interests. (38)

It was the judgment of the investigators that perceptual measures would be appropriate because of the figural character of the iconic knowledge structures being investigated. There was particular interest in the Closure Flexibility Test (Concealed Figures) because of Witkin's

(44) extensive studies using another refinement of the Gottschaldt Figures. Witkin identified a field dependence-independence factor that appeared to be stable over time and that correlated with a diversity of other perceptual measures. Because the field-dependence dimension has also been found to have factor loadings comparable to the analytic factor of the Wechsler and to Guilford's adaptive-flexibility factor, Witkin suggests it be renamed "analytic-global field approach." (44) Of the rash of new measures lumped together as cognitive styles, the field dependent-independent dimension appears to date to be the most stable. (40) To the extent that Witkin's version of the Gottschaldt test measures traits comparable to Thurstone's (Closure Flexibility Test), subjects scoring high on the latter would be characterized as being able to deal with a field analytically. Specifically, they should be more able to perceive items as discrete from the background, to reorganize the field as desired, and to impose their own structure upon it. (44) It was presumed that such subjects should be superior in tasks requiring the structuring of disordered arrays, and they should make effective use of structures in the solution of problems, both of which were required of subjects in the present study.

Individual differences in learning (differences in learner structure) may be attributed to intrinsic and extrinsic sources. Typically, it is the extrinsic sources that have been investigated--IQ, age, sex, personality, cognitive style, etc. However, Jensen suggests that most of the variance in learning is not going to be ascribable to such extrinsic sources. The issue is not the unreliability of measurement but the "reliable changes in subjects' rank order of performance on learning tasks under variations in the conditions of learning." (14:147) He recommends the study of intrinsic sources of individual differences, i.e., those sources which are intrinsic to particular learning tasks and which would be revealed in the subjects x independent variables interactions. For the present study the learner structure variable was conceived primarily in extrinsic terms (standard cognitive measures), though some intrinsic sources of individual differences were investigated such as the particular constraints or requirements of each task.

Studies employing the concept of structure with reference to cognitive behavior are not uncommon, but few are at all explicit about the character of said structure. A study by Zajonc (46) of cognitive structuring attempted to isolate and define several properties of a cognitive set (group of elements that an individual may report with relation to a stimulus object). The properties of a particular set (differentiation, similarity, complexity, organization, etc.) were computed from various equations. The data substituted in the equations were derived from the responses of subjects who first were to list on separate cards all the defining attributes they perceived for the stimulus object. Then they were to order and reorder the cards variously and answer questions about them. A study of such responses to a Picasso painting found significant differences in cognitive structuring between subjects knowledgeable in art and those not knowledgeable. Other studies by Zajonc found significant differences in the cognitive structures of audiences as a function

of their perceived role either as a receiver or transmitter of the stimulus information.

For any reader who desires to pursue further the concept of learner structure or cognitive structure or, more broadly, behavior structure, the following new books may be of interest:

1. Miller, George A.; Galanter, Eugene; and Pribram, Karl H., Plans and the Structure of Behavior, Henry Holt and Company, New York, 1960, 226 pp. (Especially the chapter entitled "Plans for Remembering")

2. Bruner, Jerome, Learning About Learning: A Conference Report, U.S. Office of Education, Cooperative Research Monograph No. 15, U.S. Government Printing Office, Washington, D.C., 1966, 276 pp. (Especially, Baldwin, Alfred L., "Information Structures")

3. Harvey, O. J.; Hunt, David E.; Schroder, Harold M., Conceptual Systems and Personality Organization, John Wiley and Sons, Inc., New York, 1961, 375 pp.

4. Schroder, Harold M.; Driver, Michael J.; Streufert, Siegfried, Human Information Processing, Holt, Rinehart and Winston, Inc., New York, 1967, 224 pp. (Especially the chapter entitled "Effects of Individual Differences in Conceptual Structure on Information Processing and Performance")

5. Gagné, Robert M., ed., Learning and Individual Differences, Charles E. Merrill Books, Inc., Columbus, Ohio, 1967, 265 pp.

Recent related studies. Studies of the effect on learning of stimulus organization, or message structure, are not confined to recent literature. The period of 1930 to 1950 yielded some classics: George Katona's Organizing and Memorizing; Frederick Bartlett's Remembering; Max Wertheimer's Productive Thinking; and William Brownell's Meaningful vs. Mechanical Learning. These works to different degrees and in different ways attested to the importance of structural factors in perception and learning. More recent work reflects notable gains in methodology, but the results tend to be consistent with earlier contentions of men like the above.

Some of the tasks in the present investigation involved verbal learning in structured contexts characterized as iconic. Certain recently reported studies involved verbal learning in structured verbal contexts. For example, it has been demonstrated (27)(28) that when two nouns in a paired-associate paradigm are presented in the context of a meaningful sentence rather than in isolation, the gain in learning is of an order that can be appreciated without benefit of statistical test. In effect, more words are learned (a sentence of five words instead of two separate words) and are learned more efficiently. A somewhat comparable finding was reported by Davidson (8) with reference to the paired-associate

learning of drawings of objects. Objects joined visually, such as a chain pictured in a bowl, were learned better than separate drawings of the chain and bowl.

In one sense these studies simply reaffirm the well-established relation between the meaningfulness of stimuli, typically words, and the number learned. However, prior studies have typically compared familiar or frequently used words with less familiar or less frequently used words. In contrast, the just-described studies employed the same pair of words or objects in both conditions, the difference being the presence or absence in the display of a relation between them. Structure was earlier defined as a relation--specifically, the interrelation of parts as dominated by the general character of the whole. It is thus possible to interpret the above findings as structure effects, for the effects are associated with a demonstrated relationship between the entities being learned.

Another study, Rohwer (29), has examined the different effects of three kinds of relationships between noun associates. The relationships compared were those expressed by verbs, prepositions, and conjunctions. For example, to the sentence "The FORK _____ the CAKE," were added the verb "cuts," the preposition "on," and the conjunction "or." These three types of relationships were experimentally compared in a paired-associate task (FORK and CAKE being the associates in this example). The three sentences were depicted both in print and in picture. The three pictorial depictions were: fork shown in motion "cutting" the cake, fork "on" the cake, and fork beside the cake ("or" condition). There were significant main effects for grade level (learning increasing from first to third to sixth grades), for verbalization (verbs being significantly better than either prepositions or conjunctions), and for depiction (action pictures, "cut," being better than the locational pictures, "on," and locational being better than the coincidental, "or"). There was no interaction with grade level. This study serves to strengthen the position that the depiction of certain relationships between noun or object pairs facilitates learning.

The present study dealt more with the types of relationships suggested by various iconic knowledge structures than with the presence or absence of relationships.

The case for the efficacy of an iconic context or structure is supported by the two markedly different types of studies to follow. Reynolds (26) used a transfer paradigm to compare six conditions of initial learning. Initial learning involved a map showing a highway intersection, an airstrip, a shopping center, a farm, etc. Beside each of eight such components was a nonsense syllable name. The transfer task was to learn eight sentences such as KOT is a pilot, BAF is a shopkeeper, etc., the names being those earlier associated in some way with the airport, shopping center, etc. Subjects in the Cognitive Structure group were given three timed trials to learn the names in their proper position on the map. Subjects in four other groups also were given three

timed trials to learn the names but under different conditions as follows: subjects in the Map-List group encountered the map on one piece of paper and the names in list form on another; subjects in the List group received the list of names but not the map; subjects in the Position-List group received the names positioned as on the map but without the map features (airport, shopping center, etc.); subjects in the S-R group received verbal paired associates such as Airstrip-KOT and Shopping Center-BAF, and these were positioned as on the map but without the map features. A control group received no initial learning. On the transfer learning task there was a significant main effect for conditions, $p < .01$. Means were compared by the Newman-Keuls method and no significant differences were found except between the Cognitive Structure group and each of the others, $p < .05$. It was only when the elements were presented in a meaningful relationship or structure that learning was optimized. The other conditions were not significantly different from the control which received no initial learning.

In another study, Paivio (24), three mediation instructions were compared in a paired-associate task. The Imagery group were asked to link the words with mental pictures, while the Verbal group were asked to link the words with another word or phrase. A control group was asked to repeat each pair a number of times. The main effect for mediation instruction was significant, the mean for the Imagery group being highest, the Verbal group next, and the Repetition group last.

Other recent studies more directly related to the tasks and results of the present study will be considered in Chapter VII Discussion, Conclusions, and Recommendations.

It would appear, in summary, that structural factors in learning are receiving current research attention, that the research designs meet current standards, and that the findings show learning to be differentially associated with structural factors.

# CHAPTER II

# REPORT OF STUDY I

As earlier indicated, this was to be an exploratory study involving relatively small numbers of subjects. This is essentially what occurred. More specifically, the study became a series of five studies each of which actually consisted of two or more related studies. Subjects were graduate education students, typically in extant class groups, though individual subjects were used for Study 4. In the effort to glean a maximum of data from a minimum of subjects, there were instances in which several tasks were given to one group of subjects. Analyses ranged from "eyeballing" the data to several non-parametric statistical tests to analysis of variance.

## Purpose

Prior to the acceptance of iconic structures as a class of knowledge structures that would be suitable for further study, an exploratory study was done. It was intended that it yield a range of subjects' responses to a range of iconic knowledge structures such that a preliminary assessment could be made.

The research questions asked were as follows:

1. Will subjects ascribe different relationships to different iconic knowledge structures?

2. What will be the judged strength of the relationship?

3. Will there be agreement between subjects as to which relationships are perceived for each type of iconic structure and for each position of elements within the structures.

## Method A

Forty-nine different iconic structures were tested. These 49 were systematic variations of four basic types: hierarchical, cyclical, linear, stellar. See Figure 3 for examples and Appendix A for a representation of each of the 49 iconic structures. The four basic types had been abstracted and classified, as indicated earlier, from a variety of instructional illustrations which were available from a previous survey

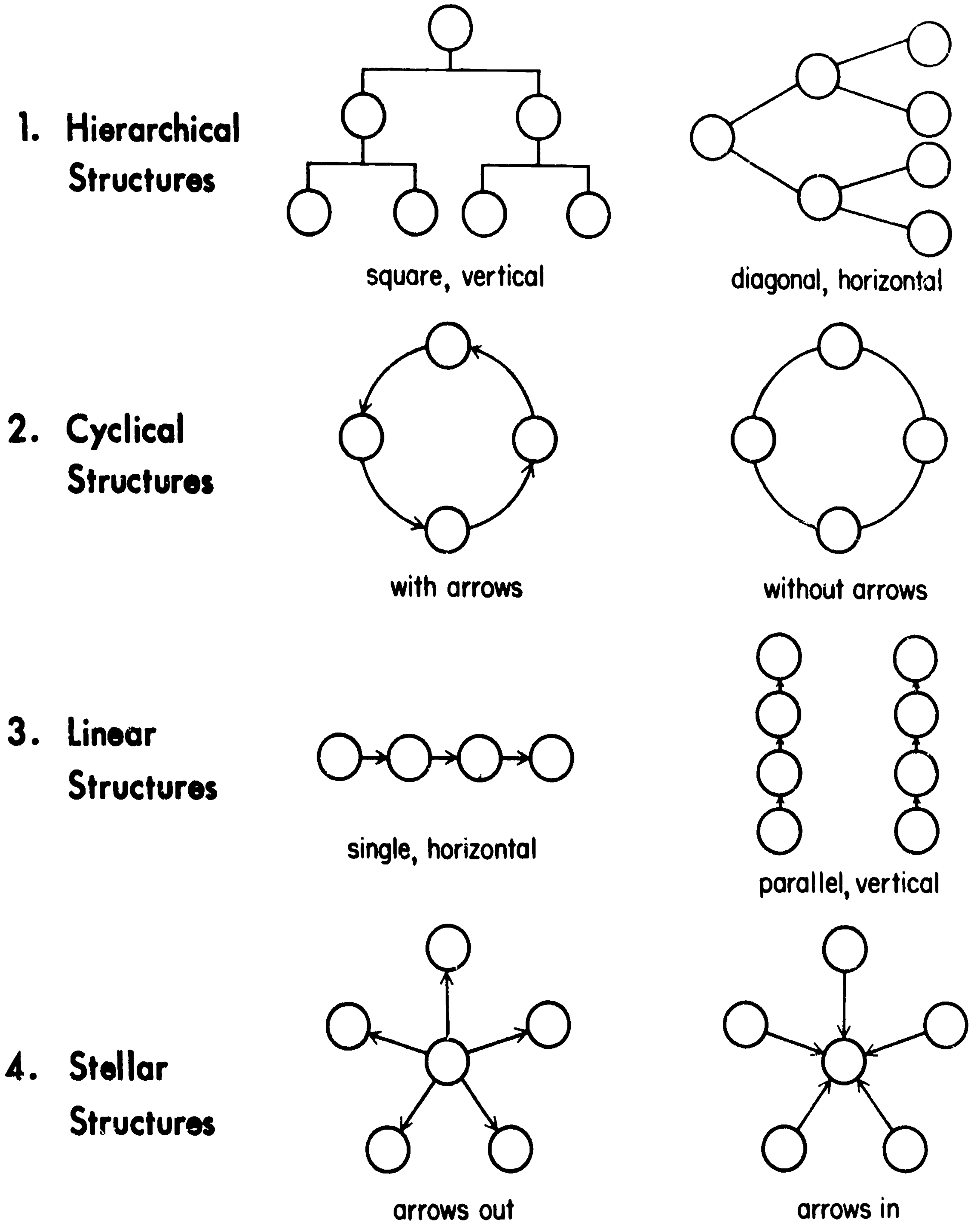



Figure 3. Two Examples of Each of Four Basic Types of Iconic Knowledge Structures Used in Study 1A

of textbooks in four subject areas.*

The task was to judge the presence or absence of a relationship between two specified elements within a structure. The pair of elements in each structure was clearly identified, as shown in Figure 4. The relationships tested were the following four: greater-lesser, before-after, cause-effect, and part-whole. These relationships were the product of an analysis of conceptual relationships as described in Chapter I.

Each structure was displayed five seconds by overhead projection**

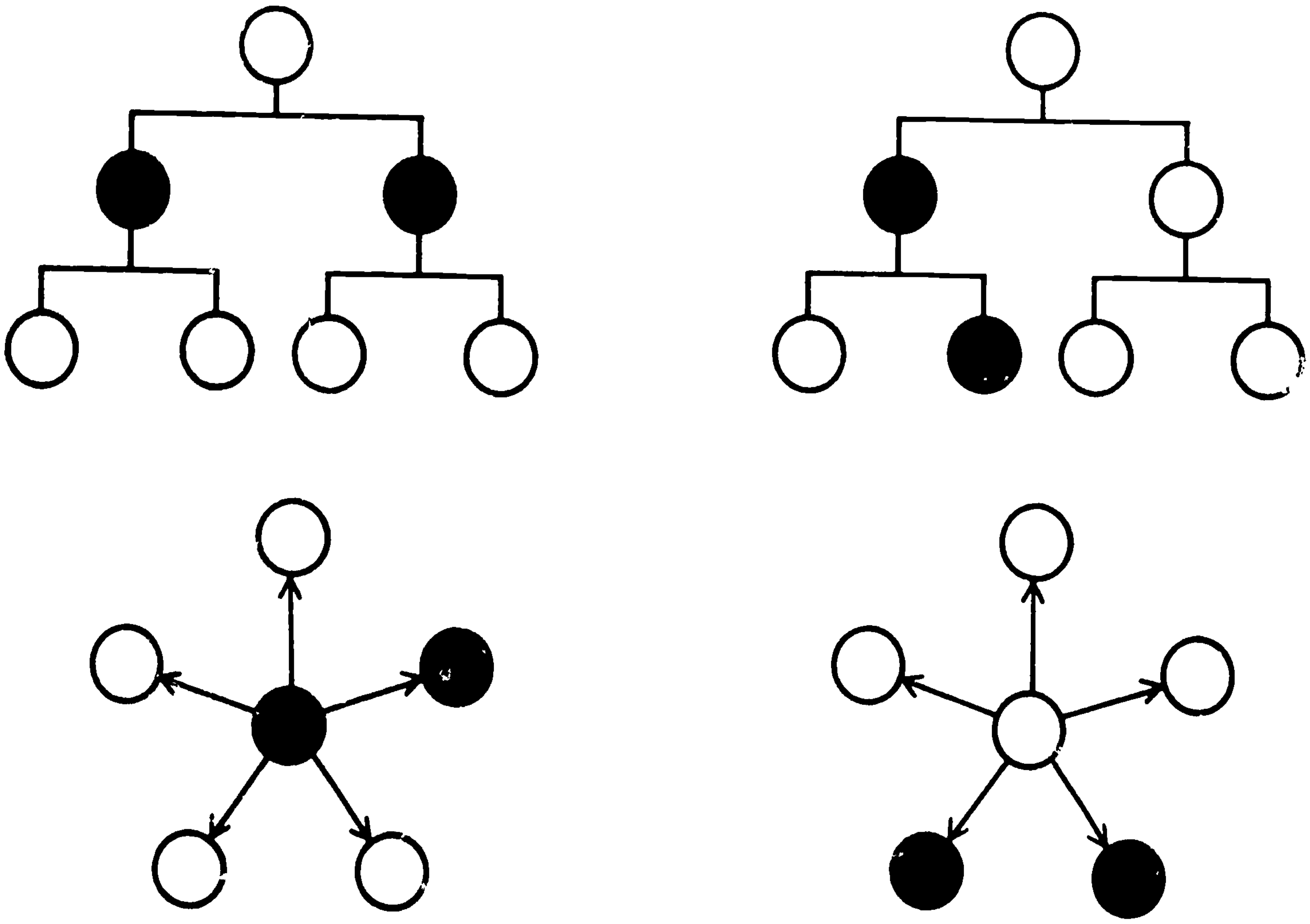


Figure 4. Examples of Variously Positioned Pairs of Elements (Solid Circles) in Hierarchical and Stellar Structures. Subjects Were Asked to Judge Selected Relationships Between the Pairs of Elements

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*Fleming, Malcolm L., Instructional Illustrations: A Survey of Types Occurring in Print Materials for Four Subject Areas, USOE Title VII Project #1381, November, 1966, 407 pp.

**It had been proposed that the experimental stimuli be motion pictures which were to have been "considered rough approximations of two representative types of subject matter structures." The subsequent refinement of the concept of knowledge structure permitted the use of less complex media. Consequent budget economies made possible the more extensive study of the three basic variables through a series of five studies.

to a group of 15 subjects, who responded "yes" or "no" on an answer sheet to the judged presence or absence of each relationship. Subjects first made all greater-lesser judgments across the sample of structures, then made all before-after judgments, etc.

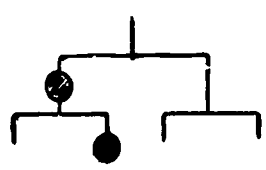
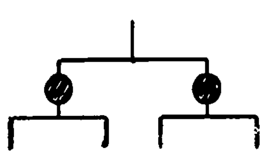
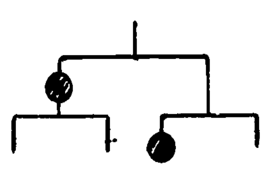
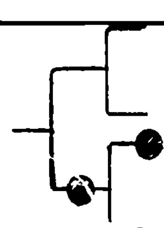
Subjects were two convenience samples of 15 graduate students in education. Types of structures were assigned to groups such that approximately an equal number of the four basic types (hierarchical, cyclical, linear, and stellar) were encountered by each group.

## Results A

Because the study was exploratory, only the most consistent findings will be discussed here. All frequency data are given in Appendix A.

The frequency data for hierarchies vary sharply with the relative position of the pair of elements in the hierarchy. Selected positions are illustrated in Table 1. Position 1 strongly suggests all four types

TABLE 1. FREQUENCIES OF "YES" RESPONSES MADE TO FOUR POSITIONS OF ELEMENTS IN HIERARCHICAL STRUCTURES WITH REFERENCE TO FOUR TYPES OF RELATIONSHIPS BETWEEN ELEMENTS (N = 15)

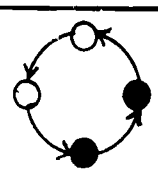
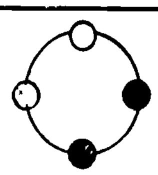
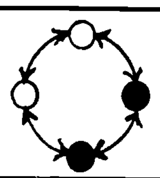
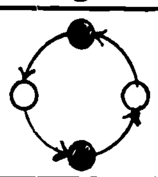
| Position of elements | | Types of relationships | | | |
|---|---|---|---|---|---|
| | | Greater-lesser | Before-after | Cause-effect | Part-whole |
| 1 |  | 15 | 14 | 13 | 15 |
| 2 |  | 0 | 0 | 2 | 1 |
| 3 |  | 14 | 8 | 1 | 1 |
| 4 |  | 14 | * | * | 15 |

*Not tested

of relationships; position 2 suggests none; position 3 primarily suggests greater-lesser; and position 4 (for the two relationships tested) strongly suggests the same relationships as does its vertical counterpart, position 1.

As shown in Table 2, the frequency data for cycles vary sharply depending on the presence or absence of arrows (positions 1 to 3) and the relative positions of pairs of elements (positions 1 and 4). Unidirectional arrows (position 1) strongly suggest before-after and cause-effect relationships; bidirectional arrows (position 3) mildly suggest cause-effect, while the absence of arrows (position 2) suggests none of the four relationships. Although adjacent elements (position 1) suggest both before-after and cause-effect, opposite elements (position 4) suggest (for the relationships tested) primarily before-after.

TABLE 2. FREQUENCIES OF "YES" RESPONSES MADE TO FOUR POSITIONS OF ELEMENTS AND ARROWS IN CYCLICAL STRUCTURES WITH REFERENCE TO FOUR TYPES OF RELATIONSHIPS BETWEEN ELEMENTS (N = 15)

| Position of elements | | Types of relationships | | | |
|---|---|---|---|---|---|
| | | Greater lesser | Before-after | Cause-effect | Part-whole |
| 1 |  | 6 | 13 | 13 | 5 |
| 2 |  | 0 | 2 | 3 | * |
| 3 |  | 1 | 3 | 7 | * |
| 4 |  | 2 | 12 | 8 | * |

*Not tested.

As shown in Table 3, the frequency data for linear structures vary in relation to the direction of the line (vertical or horizontal) and the presence or absence of arrows. Clearly, lines without arrows (positions 1 and 3) do not strongly suggest any of the relationships tested. Lines with arrows (positions 2 and 4) suggest cause-effect relationships, whether the lines are horizontal or vertical. However,

the vertical line with arrows strongly suggests greater-lesser, while the same line in horizontal position does not.

TABLE 3. FREQUENCIES OF "YES" RESPONSES MADE TO FOUR POSITIONS OF ELEMENTS AND ARROWS IN LINEAR STRUCTURES WITH REFERENCE TO THREE TYPES OF RELATIONSHIPS BETWEEN ELEMENTS (N = 15)

| Position of elements | | Types of relationships | | |
| --- | --- | --- | --- | --- |
| | | Greater-lesser | Before-after | Cause-effect |
| 1 |  | 2 | 1 | 3 |
| 2 |  | 7 | 14 | 13 |
| 3 |  | 6 | * | 2 |
| 4 |  | 12 | * | 15 |

*Not tested.

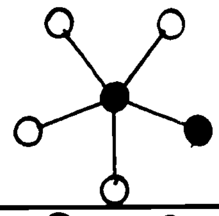
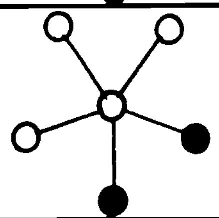
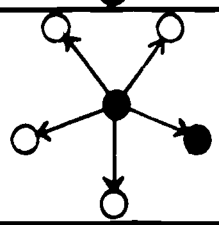
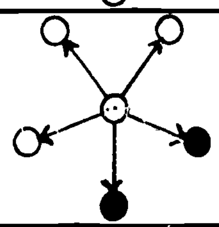
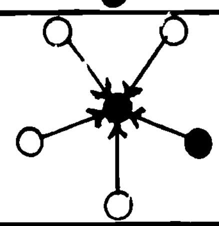
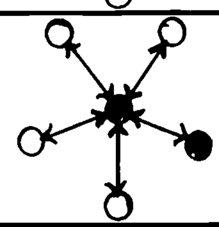
As shown in Table 4, the frequencies for the stellar structure vary with the relative position of the pair of elements (positions 1 and 2, 3 and 4), but are essentially independent of arrows. Positions 1, 3, 5, and 6 all have the pair of elements in the same location and all strongly suggest cause-effect and part-whole. These relationships were in spite of arrow variations--none, unidirectional inward, unidirectional outward, and bidirectional. In contrast, elements in positions 2 and 4 show none of the relationships tested.

## Method B

Twelve different iconic structures were tested, two each of six types.

The task differed from Method A in two ways: (1) subjects were to rate the degree of perceived relationship between elements and (2) the

TABLE 4. FREQUENCIES OF "YES" RESPONSES MADE TO SIX POSITIONS OF ELEMENTS AND ARROWS IN STELLAR STRUCTURES WITH REFERENCE TO FOUR TYPES OF RELATIONSHIPS BETWEEN ELEMENTS (N = 15)

| Position of elements | | Types of relationships | | | |
|---|---|---|---|---|---|
| | | Greater-lesser | Before-after | Cause-effect | Part-whole |
| 1 |  | 15 | 9 | 12 | 14 |
| 2 |  | 1 | 0 | 0 | 1 |
| 3 |  | 14 | * | 14 | 14 |
| 4 |  | 0 | * | 1 | 0 |
| 5 |  | * | * | 12 | 15 |
| 6 |  | * | * | 13 | 12 |

*Not tested.

entire structure (all elements and relationships) was to be considered. Task A and B subjects were the same.

Each structure was displayed by overhead projection for as long as the subjects required for making judgments and recording them on rating scales on their response sheets.

The rating scale provided for subjects was as follows:

5 -- Definitely shows relationship
4 -- Shows relationship
3 -- Uncertain
2 -- Does not show relationship
1 -- Definitely does not show relationship

## Results B

For each of the 12 iconic structures the ratings (1 to 5) were averaged for each relationship. The means are shown in Table 5. The mean ratings range from 1.40, which indicates that a relationship is clearly not shown, to 4.93, which indicates that a relationship is clearly shown. A simplified presentation of the data is given in Tables 6 and 7, wherein mean ratings $>3.50$, i.e., those structures rated as showing a relationship of some degree are marked with asterisks. The data for the hierarchies, Table 6, show that all four types of hierarchies were rated as showing all four relationships. The mean rating for five of the hierarchy-relationship combinations was $>4.50$, indicating the relationships were definitely shown (indicated in Table 6 by two asterisks).

TABLE 5. MEANS OF RATINGS OF TWELVE ICONIC STRUCTURES (ENTIRE STRUCTURES) WITH REFERENCE TO FOUR TYPES OF RELATIONSHIPS BETWEEN ELEMENTS

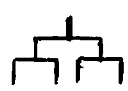
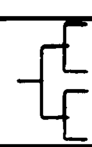
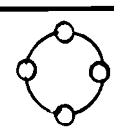
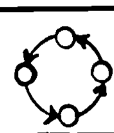
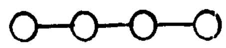
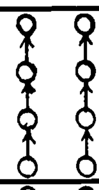
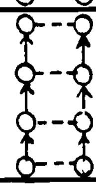
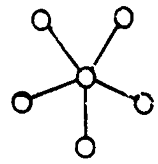
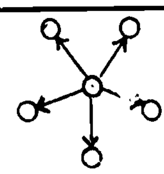
| Types of iconic structures | | | Types of relationships | | | |
|---|---|---|---|---|---|---|
| | | | Greater-lesser | Before-after | Cause-effect | Part-whole |
| Square Hierarchy | Vertical |  | 4.66 | 4.06 | 3.86 | 4.73 |
| | Horizontal |  | 4.40 | 4.06 | 4.06 | 4.60 |
| Diagonal Hierarchy | Vertical |  | 4.60 | 4.20 | 4.13 | 4.93 |
| | Horizontal |  | 4.33 | 3.60 | 3.80 | 4.40 |
| Cyclical | No arrows |  | 1.46 | 2.13 | 2.00 | 1.66 |
| | Arrows |  | 2.13 | 3.26 | 3.93 | 1.80 |

TABLE 5 (Continued)

| Types of iconic structures | | | Types of relationships | | | |
|---|---|---|---|---|---|---|
| | | | Greater-lesser | Before-after | Cause-effect | Part-whole |
| Linear | No arrows |  | 1.40 | 2.13 | 1.93 | 1.80 |
| | Arrows |  | 2.73 | 4.46 | 4.13 | 1.93 |
| Parallel Linear | No lines |  | 2.93 | 3.80 | 3.93 | 2.13 |
| | Lines |  | 3.73 | 3.86 | 3.73 | 2.46 |
| Stellar | No arrows |  | 4.13 | 1.86 | 3.06 | 4.00 |
| | Arrows |  | 3.93 | 3.13 | 4.33 | 4.40 |

N = 15 raters, reliability of mean ratings = .90 and .94.

TABLE 6. HIERARCHICAL STRUCTURES WHICH WERE RATED AS SHOWING ONE OR MORE OF FOUR TYPES OF RELATIONSHIPS BETWEEN ELEMENTS

| Types of iconic structures | | Greater-lesser | Before-after | Cause-effect | Part-whole |
|---|---|---|---|---|---|
| Square Hierarchy | Vertical | * * | * | * | * * |
| | Horizontal | * | * | * | * * |
| Diagonal Hierarchy | Vertical | * * | * | * | * * |
| | Horizontal | * | * | * | * |

* = Mean rating > 3.50 but < 4.50, i.e. rated as showing relationship.

** = Mean rating > 4.50, i.e. rated as <u>definitely</u> showing relationship.

TABLE 7. CYCLICAL, LINEAR, AND STELLAR STRUCTURES WHICH WERE RATED AS SHOWING ONE OR MORE OF FOUR TYPES OF RELATIONSHIPS BETWEEN ELEMENTS

| Types of iconic structures | | Greater-lesser | Before-after | Cause-effect | Part-whole |
|---|---|---|---|---|---|
| Cyclical | No arrows | | | | |
| | Arrows | | | * | |
| Linear | No arrows | | | | |
| | Arrows | | * | * | |
| Parallel Linear | No lines | | * | * | |
| | Lines | * | * | * | |
| Stellar | No arrows | * | | | * |
| | Arrows | * | | * | * |

* = Mean rating $>3.50$ but $<4.50$, i.e. rated as showing relationship.

In contrast, Table 7 shows that the other types of structures were rated much more selectively with regard to the four relationships. None of these ratings reached the 4.50 level (definitely showing relationship), though two reached or exceeded 4.40.

Each rating in Table 5 is the mean of 15 ratings of graduate students. Half the ratings were by one group of 15 and half by another. An estimate of the reliability of these mean ratings was computed for each group of raters. The following equation was employed, Winer (43:126):

$$r = 1 - \frac{\text{Mean Square within (things rated)}}{\text{Mean Square between (things rated)}}$$

The resulting estimate of the reliability of the mean ratings shown in Table 5 was .90 for one group of raters and .94 for the other group.

## Findings and Discussion

Three research questions were asked in this preliminary assessment of iconic structures as a useful class of knowledge structures.

1. Will subjects ascribe different relationships to different iconic knowledge structures?

The data obtained from both Method A and Method B suggest that subjects differentially attributed relationships (greater-lesser, before-after, cause-effect, part-whole) to iconic structures (variations of hierarchical, linear, cyclical, and stellar). Though no statistical analyses are presented for this exploratory study, "yes" responses ranging from 0 to 100% of the 15 subjects rating each structure give adequate "eyeball" evidence to support the claim that differential responses were made.

For some iconic structures there was little distinction made as to which of the four relationships was suggested. A hierarchical structure, when considered as a whole, strongly suggested all four relationships. This tended to be the case even where the structure was displayed on its side. However, when certain pairs of elements within the hierarchy were considered, markedly different relationships were ascribed to different arrangements of elements.

For the other iconic structures the subjects were more selective in the relationship(s) ascribed. The linear structure with arrows, for example, was primarily ascribed before-after and cause-effect relationships, while the stellar structure without arrows was ascribed greater-lesser and part-whole relationships.

Certain variations within basic types of structures appeared to be reflected in changes in response patterns. Most consistent in this regard appeared to be variations in the position of elements within structures and variations in the use of arrows.

In sum, a qualified positive answer to question 1 can be made.

2. What will be the judged strength of the relationships?

Judged on a 1-5 rating scale, strength of relationship varied with the type of structure (mean range 1.40-4.93). The 48 structure-relationship combinations tested in Method B were distributed across the five ratings as follows:

| | |
|---|---|
| 5--Definitely shows relationship | 5 structures (10%) |
| 4--Shows relationship | 24 structures (50%) |
| 3--Uncertain | 5 structures (10%) |
| 2--Does not show relationship | 12 structures (25%) |
| 1--Definitely does not show relationship | 2 structures ( 5%) |

3. Will there be agreement between subjects as to which relationships are perceived for each type of iconic structure and for each position of paired elements within the structures?

If there was equivocation among subjects or if chance only were operating, there should have been a predominance of structures for which about half, perhaps six to nine, of the 15 subjects would have responded "yes" (or "no"). The inverse occurred. For the 55 structure-relationship

combinations reported in Tables 1 to 4, there was a predominance of structures (47 or 85%) for which either 0-3 subjects or 12-15 subjects responded "yes." Only 8 or 15% of the structures were in the equivocal part (middle half) of the range, i.e. where 4-11 subjects responded "yes." This unequivocal finding was for the yes-no judging of the relationship between certain paired elements within structures. When entire structures were rated on a 1-5 scale the reliability of average ratings was .90 for one group of 15 raters and .94 for the other.

The weight of the evidence supports an affirmative answer to question #3.

# CHAPTER III

## REPORT OF STUDY 2

### Purpose

Following the initial assessment of the first variable, knowledge structure, an initial assessment of the second variable, message structure, was undertaken. Study of the temporal dimension of message structure had been proposed. Consequently, Study 2 was intended as a preliminary investigation of the temporal orders in which messages might be presented.

The research questions were as follows:

1. Given knowledge in the form of certain iconic knowledge structures, in what temporal order would subjects choose to encounter the constituent elements of such structures?

2. Would the temporal order of encounter chosen by subjects be sufficiently consistent and logical to warrant further study?

### Method

Four types of iconic structures were tested: hierarchical, cyclical, linear, and parallel. Nonsense syllables were placed within each structure to suggest substantive elements. (Structures in the prior study were empty.) One location within each structure contained a question mark (see Figures 5 and 6 for a representation of each of the structures).

Subjects were to direct their attention to the unknown (?) element. Their task was to choose the temporal order in which they would prefer to investigate each structure in order to identify what the (?) stood for. The element judged to give the most information about (?) was to be chosen first, the element next most informative was to be chosen second, etc.

Structures were presented by overhead projection and were displayed until all subjects completed responding. Subjects responded on answer sheets by listing in 1, 2, 3 order the nonsense names of the elements they would want revealed in order to identify the (?) element.

There were 40 subjects, all of whom were enrolled in a graduate education course. Each responded to the same four structures.

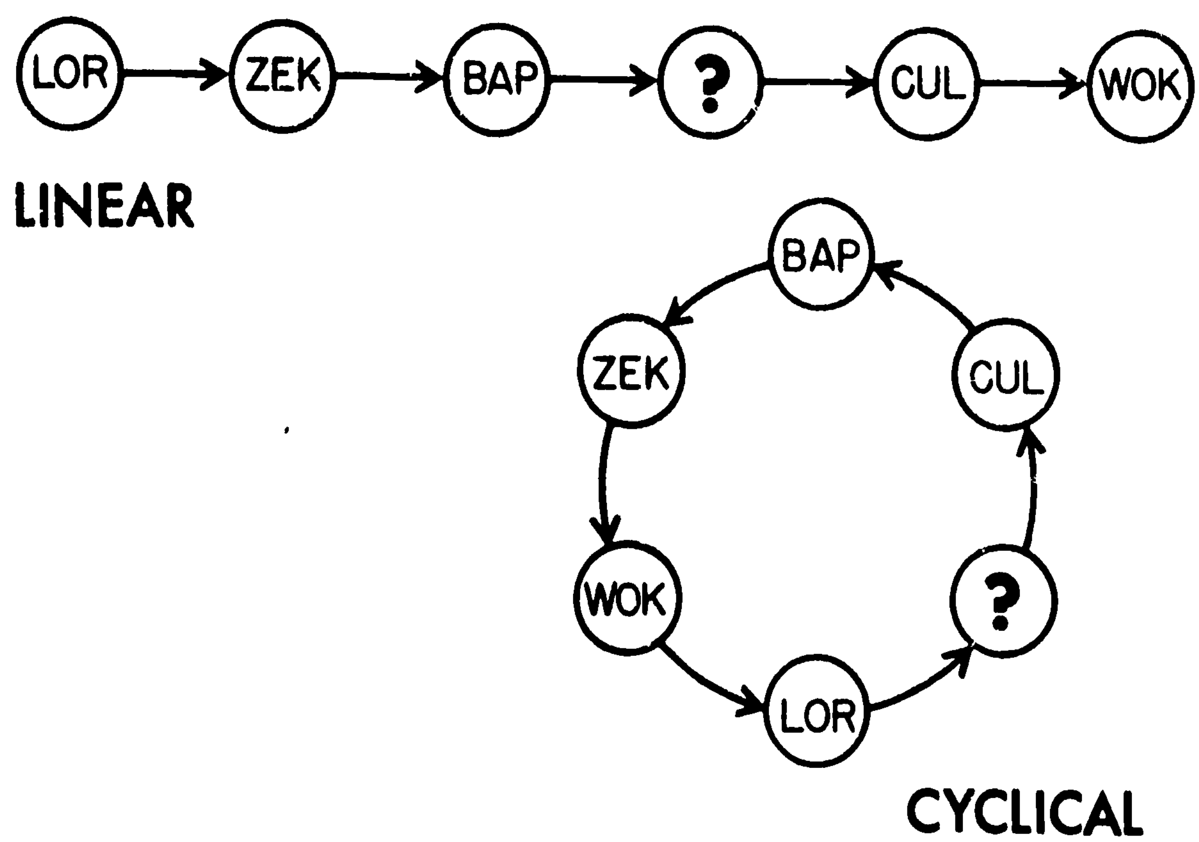



Figure 5. Two of Stimuli Employed In Study 2. These Iconic Structures Were Similar to Those in Study 1, Except That Nonsense Syllables to Suggest Substantive Elements Were Placed in the Empty Positions

## Results

Frequencies of responses were tabulated for each structure. It was possible to identify, primarily on the basis of the first few choices made by the subjects, a few most-frequently-occurring patterns of response. Data are presented primarily for "eyeballing" purposes, though a few Chi-square analyses were done.

For the linear structure (see Figure 5), Table 8 shows the frequencies of responses for the first through the fifth choices. The most-frequently-occurring first choices were LOR and BAP; in fact, 34 of the 39 first choices were before or to the left of the question mark (?) location. The 11 subjects who listed the syllables in a LOR, ZEK, BAP, CUL, WOK order, or in an exact opposite order, were designated "Stringers," because they held to the order in which the syllables were "strung" together in the structure. See Figure 5. The 11 who began BAP, CUL, or the reverse, were called "Bracketers" because they bracketed the unknown

TABLE 8. FREQUENCIES OF RESPONSES TO EACH POSITION IN LINEAR STRUCTURE FOR EACH OF THE FIVE CHOICES

| Number of choice | Position in linear structure | | | | |
|---|---|---|---|---|---|
| | LOR | ZEK | BAP | CUL | WOK |
| 1st | 17 | 1 | 16 | 2 | 4 |
| 2nd | 3 | 16 | 2 | 12 | 7 |
| 3rd | 4 | 11 | 18 | 3 | 4 |
| 4th | 4 | 8 | 3 | 19 | 6 |
| 5th | 12 | 4 | 1 | 4 | 19 |

N = 40

location. The six subjects who began LOR, WOK, or the reverse, were called "Extremists." The remaining 11 followed no consistent pattern and were called "Odd Fellows." Thus, though several distinct patterns occurred, none predominated under these conditions. However, there was a stronger overall tendency toward the Stringer pattern (or at least a left-right pattern) than evidenced by the 11 who followed it consistently. For, as is apparent in Table 8, the overall most frequent first, second, third, fourth, and fifth choices were, respectively, LOR, ZEK, BAP, CUL, WOK, i.e., essentially a Stringer pattern. Several sub-classes of Bracketer and Extremist categories were identifiable, as shown in Appendix B.

A Chi-square One-Sample test of the first choices for the linear structure, Table 9, indicated that these choices differed from expected frequencies (8 per cell) by an amount significantly exceeding chance ($p < .001$).

For the cyclical structure (see Figure 5), the frequencies are shown in Table 10 for the first through fifth choices. Position LOR was the most frequent first choice and CUL was the most frequent second choice, indicating that subjects favored either the immediately preceding or succeeding position, i.e., the "before-after," "cause-effect" positions with reference to the unknown position. Bracketers (first two choices being LOR and CUL or the reverse) constituted half the sample. There were 14 Stringers (CUL, BAP, ZEK, WOK, LOR, or the reverse), and five were Odd Fellows. Several sub-classes of Bracketers were identified, as shown in Appendix B.

A Chi-square One-Sample Test of the first choices for the cyclical structure, Table 9, indicated that these frequencies differed from the expected by an amount significantly exceeding chance ($p < .001$).

TABLE 9. ANALYSIS OF FIRST-RESPONSE FREQUENCIES BY POSITION IN LINEAR AND CYCLICAL STRUCTURES

| Choice | Position in linear structure | | | | | |
|---|---|---|---|---|---|---|
| | LOR | ZEK | BAP | CUL | WOK | |
| 1st | 8 / 17 | 8 / 1 | 8 / 16 | 8 / 2 | 8 / 4 | |
| Chi-square = 30.75, p <.001 at 4df | | | | | | 40 |

| Choice | Position in cyclical structure | | | | | |
|---|---|---|---|---|---|---|
| | CUL | BAP | ZEK | WOK | LOR | |
| 1st | 7.8 / 12 | 7.8 / 4 | 7.8 / 0 | 7.8 / 0 | 7.8 / 23 | |
| Chi-square = 49.33, p <.001 at 4df | | | | | | 39 |

TABLE 10. FREQUENCIES OF RESPONSES TO EACH POSITION IN CYCLICAL STRUCTURE FOR EACH OF THE FIVE CHOICES

| Number of choice | Position in cyclical structure | | | | |
|---|---|---|---|---|---|
| | CUL | BAP | ZEK | WOK | LOR |
| 1st | 12 | 4 | 0 | 0 | 23 |
| 2nd | 20 | 9 | 4 | 4 | 2 |
| 3rd | 2 | 10 | 13 | 12 | 2 |
| 4th | 0 | 9 | 13 | 15 | 2 |
| 5th | 5 | 7 | 9 | 8 | 10 |

N = 39

For the hierarchical structure (see Figure 6), the frequencies are shown for the first through fifth choices in Table 11. Over half of the subjects made LOR a first choice. BAP was the most frequent

second choice, BAP and PID were the most frequent third choices, and PID was the most frequent fourth choice. Thus, subjects tended to begin at the top of the hierarchy and work directly down toward the unknown, though a few started at the bottom (HUP) and worked up. The most frequent initial pairs of choices were LOR and BAP (14 subjects), LOR and ZEK (eight subjects), and HUP and FIK (five subjects). The most frequent three-choice series were LOR, BAP, PID (eight subjects) and LOR, ZEK, BAP (seven subjects).

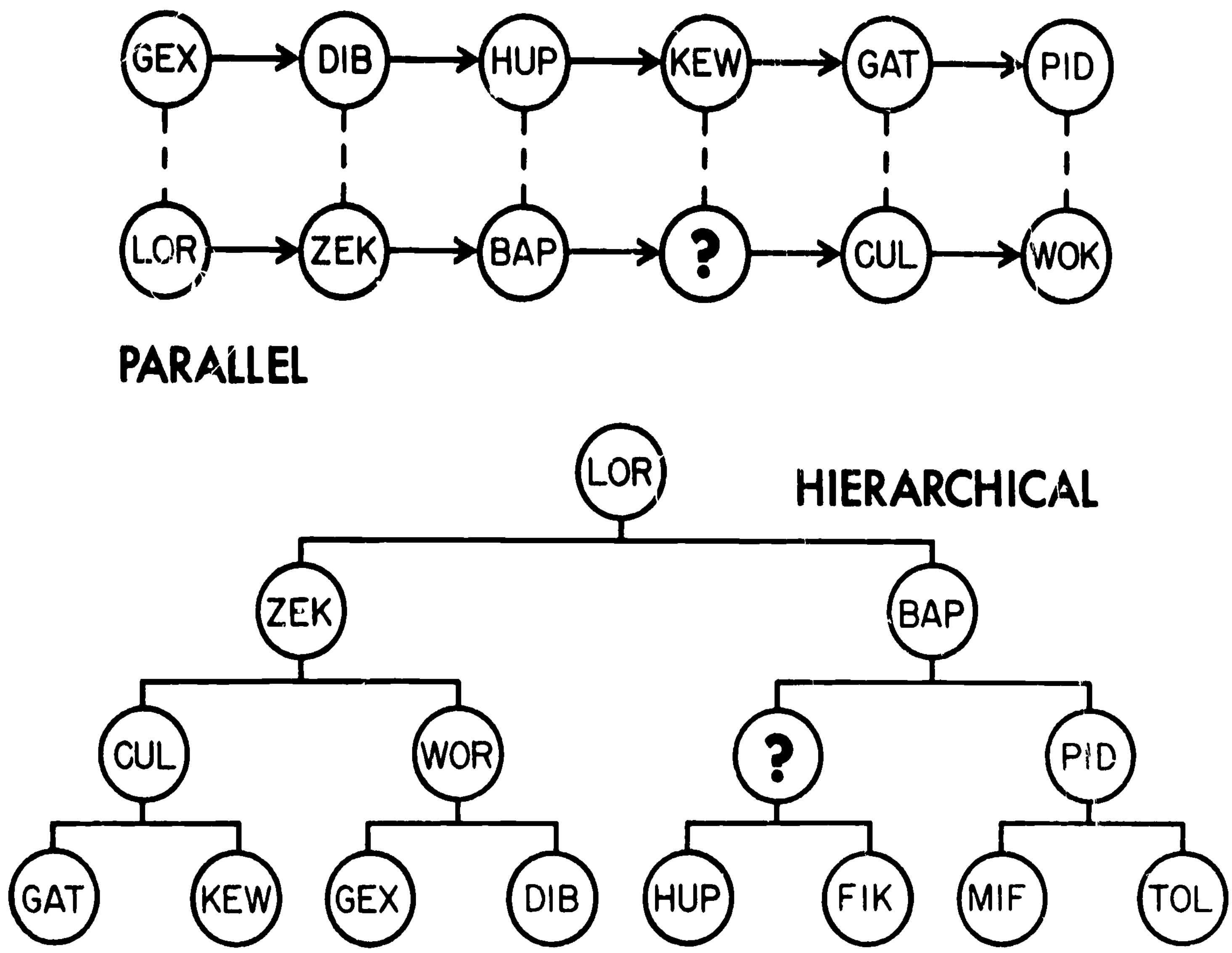



Figure 6. Two of Stimuli Employed in Study 2

Results for the parallel structure (see Figure 6) were essentially comparable to the linear structure, though more complex because the greater number of elements permitted more response patterns. Frequencies are given in Appendix B. Most frequent first choices were BAP and KEW. Consistent response patterns were not readily identifiable.

TABLE 11. FREQUENCIES OF RESPONSES TO EACH POSITION IN HIERARCHICAL STRUCTURE FOR FIRST FIVE CHOICES

| Number of choice | LOR | ZEK | BAP | CUL | WOR | PID | GAT | KEW | GEX | DIB | HUP | FIK | MIF | TOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st | 23 | 1 | 6 | 1 | | 3 | 1 | | | | 5 | | | |
| 2nd | 2 | 8 | 17 | 1 | | 3 | | | | | 4 | 5 | | |
| 3rd | 3 | 3 | 11 | 1 | 1 | 10 | | 1 | | | 5 | 5 | | |
| 4th | 2 | 4 | 3 | 6 | 1 | 10 | 3 | | | | 2 | 6 | 3 | |
| 5th | 2 | 3 | | 5 | 4 | 5 | 1 | 2 | 1 | | 8 | 1 | 5 | 3 |

N = 40

## Findings and Discussion

Two research questions were considered in this initial assessment of the temporal order variable in message design.

1. Given knowledge in the form of certain iconic knowledge structures, in what temporal order would subjects choose to encounter the constituent elements of such structures?

In several respects the results reflect a simplistic and obvious approach by subjects to the solution of temporal order problems. Instructions to subjects provided several concrete examples and were intended not only to inform but also to arouse interest in the task. But perhaps the challenge as stated was not sufficient or the structures contained too few elements and presented too few options.

Whatever the adequacy of the task, the temporal order response patterns fell largely into two classes, the Stringer and the Bracketer. The Stringer pattern appears to be orderly but inefficient for this task. Further, the likelihood of its being influenced heavily by left-to-right reading habits reduces its credibility as a response pattern that is adaptive to either the structure or the task. The linear and parallel structures, being arranged more like lines of text, are more subject to this limitation than are the cyclical and hierarchical structures. The Bracketer strategy appears the most appropriate for the task of identifying the unknown element and also appears less subject to left-right reading tendencies.

From another more substantive viewpoint the left-right tendency can be seen as a preference for "cause" to precede "effect" and "before" to precede "after." These two relationships were unequivocally assigned by

Study 1 subjects to the linear and cyclical structures with arrows. It is therefore tenable to interpret left-right responses to those structures in this study as at least partially substantive rather than simply as habitual reading behavior.

2. Would the temporal order of encounter chosen by subjects be sufficiently consistent and logical to warrant further study?

There was some evidence of consistency of response pattern. Responses of over half the subjects were in the same category for both linear and cyclical structures, eleven being repeat Bracketers, nine being repeat Stringers, and four being repeat Old Fellows.

Response patterns to the hierarchy showed a marked tendency to begin at or near the top of the hierarchy and move downward toward the unknown (the question mark), then beside it, and then below it. This could be interpreted as a preference for superordinate information at the outset of a learning sequence, i.e., beginning with an overview of a subject or the more general or inclusive categories under which the subordinate concepts can be placed. This response pattern can also be interpreted in reading terms, top to bottom, and line by line. However, responses to some hierarchies in Study #1 were consistent regardless of the orientation of the hierarchy--on its side or upside down, both of which would violate normal reading orientations.

In sum, a positive answer to question 2 seems supportable.

# CHAPTER IV

# REPORT OF STUDY 3

## Purpose

Of the three basic variables--knowledge structure, message structure, and learner structure--only the last remained for an initial investigation. In addition, it was judged important both to replicate and refine aspects of earlier studies and to do so with a larger number of subjects.

The research questions asked were as follows:

1. Is there a correlation between subjects' responses to iconic knowledge structures and their responses to standard cognitive measures?

2. Will the responses to iconic structures by another sample of graduate education students differ from those obtained for comparable tasks in Study 2?

3. Will the addition of constraints to the task of choosing temporal order of encounter alter the pattern of responses?

4. When subjects are given the task of finding out about all elements in an entire structure instead of about one specified element (as in Study 2) will their choices of temporal order of encounter follow identifiable patterns?

## Method A

The method was the same as for Study 2. Stimuli were the same four types of iconic knowledge structures (linear, cyclical, hierarchical, parallel) containing nonsense names as elements and one unknown element marked with a (?). Each structure, Figure 7, was projected for a time sufficient for subjects to list the nonsense names in the order the subjects chose as optimum for identifying the unknown (?) element. See Appendix C for instructions to subjects.

The 60 subjects were in two graduate classes in education. The same structures and tasks were presented to both classes.

In contrast to Study 2, the subjects were given a test several days prior to the administration of the task. The test (Siegel Test of Educational Set) was purported to indicate preferences for fact-seeking as opposed to concept-seeking (32). There was a possibility that scores on the Siegel Test might correlate with certain task scores. For example,

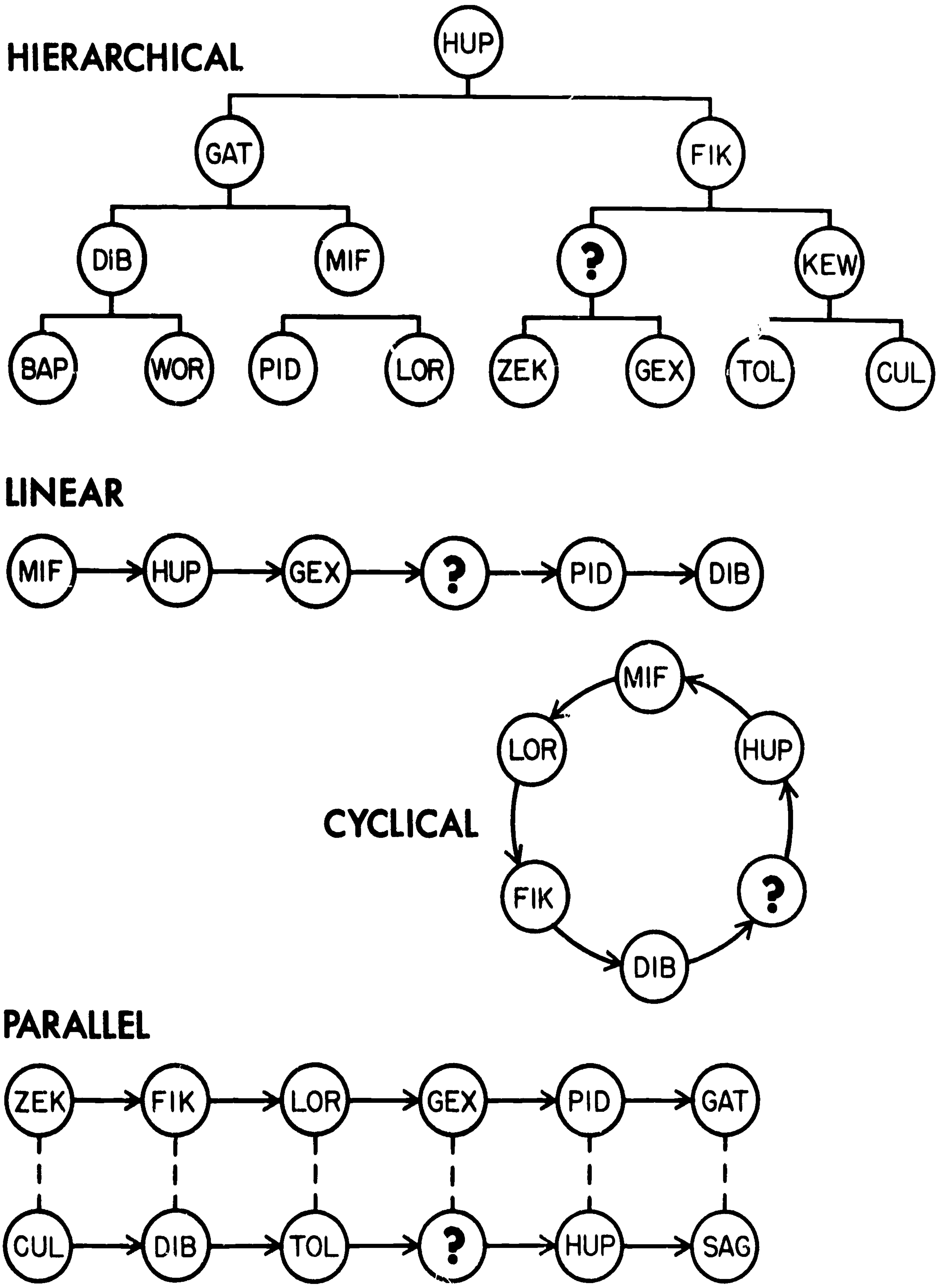



Figure 7. Stimuli Employed in Study 3. The Iconic Structures Were Similar to Those for Study 2 But With Different Nonsense Syllables for Methods A and B, Free and Constrained

fact-seeking tendencies might be correlated with preferences for subordinate elements in a hierarchy, while concept seeking might be correlated with preferences for superordinate elements.

## Results A

In Table 12 are frequencies of responses in each category for Study 2 as compared to Study 3. Chi-square analyses show that the Study 2 data do not differ from Study 3 data by an amount significantly greater than chance. These data refer to linear and cyclical structures, Figure 7. The hierarchical and parallel structure data were not compared.

The relationship between Siegel scores and task response pattern was examined. The range of Siegel scores was divided into an upper half (High Siegel) and lower half (Low Siegel). In Table 13 the pattern of responses to the task are compared for High and Low Siegel groups. Chi-square analyses indicate no significant differences in the pattern of responses to either linear or cyclical structures as a function of high or low Siegel scores.

Similarly, the relation between Siegel scores and responses to the hierarchy was found to be non-significant.

## Method B

The method was the same as Method A (as well as in Study 2) except that constraints were added to make the task appear more challenging and difficult. Subjects were to choose as few elements as possible and choose them in the most strategic order for finding the identity of the unknown (?) element. Further, they were told that a computer had been used at MIT to determine the most efficient strategy and that Harvard graduate students had been able to rate the structures with about 85% efficiency. See Appendix C for instructions to the subjects.

Except for the above addition in constraints, stimuli were administered and data collected in the same way as for Method A, and the same subjects were used. Structures were the same (Figure 7) but with changed nonsense syllables.

## Results B

The change in response pattern from the free condition (Method A) to the constrained condition (Method B) is shown in Table 14 for the

TABLE 12. COMPARISON OF STUDY 2 WITH STUDY 3 DATA: RESPONSE FREQUENCIES OF SEVERAL TYPES FOR LINEAR AND CYCLICAL STRUCTURES

| Study | Responses to linear structure | | | | | Responses to cyclical structure | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bracketer | Extremist | Stringer | Odd Fellow | | Bracketer | Stringer | Odd Fellow | |
| #2 | 13.7<br>11 | 4.3<br>6 | 9.8<br>11 | 11.0<br>11 | 39 | 22.5<br>20 | 13<br>14 | 3.5<br>5 | 39 |
| #3 | 21.2<br>24 | 6.6<br>5 | 15.1<br>14 | 16.9<br>17 | 60 | 34.5<br>37 | 20<br>19 | 5.4<br>4 | 60 |
| | 35 | 11 | 25 | 28 | 99 | 57 | 33 | 9 | 99 |

Chi-square = 2.18, $p < .70$ at df = 3 Chi-square = 1.59, $p < .50$ at df = 2

TABLE 13. COMPARISON OF TASK RESPONSE FREQUENCIES OF THREE TYPES FOR HIGH AND LOW SIEGEL SCORE SUBJECTS (LINEAR AND CYCLICAL STRUCTURES)

| Siegel score | Linear structure | | | | Cyclical structure | | | |
|---|---|---|---|---|---|---|---|---|
| | Bracketer | Stringer | Other | | Bracketer | Stringer | Other | |
| High | 12<br>12 | 7<br>9 | 11<br>9 | 30 | 18.5<br>18 | 9.5<br>10 | 2<br>2 | 30 |
| Low | 12<br>12 | 7<br>5 | 11<br>13 | 30 | 18.5<br>19 | 9.5<br>9 | 2<br>2 | 30 |
| | 24 | 14 | 22 | 60 | 37 | 19 | 4 | 60 |

Chi-square = 1.87, $p < .50$ at 2 df Chi-square = 0.08, $p < .98$ at 2 df

TABLE 14. COMPARISON OF RESPONSE FREQUENCIES TO FREE (METHOD A) AND CONSTRAINED (METHOD B) CONDITIONS FOR LINEAR AND CYCLICAL STRUCTURES

| | Linear | | Cyclical | |
|---|---|---|---|---|
| | Free | Constrained | Free | Constrained |
| Bracketers | 25 | 41 | 37 | 48 |
| Stringers | 14 | 4 | 19 | 6 |
| Extremists and Odd Fellows | 21 | 15 | 4 | 6 |
| Total | 60 | 60 | 60 | 60 |

linear and cyclical structures. As can be seen, the largest change in response frequencies for both structures was from a Stringer to a Bracketer pattern. The McNemar Test for the Significance of Change in two related samples (33) was applied to the data as shown in Table 15. Interest centers in cells A and D which show frequencies of subjects who changed response type in going from the free to the constrained condition. The test indicates that subjects showed a significant tendency ($p < .01$) to change responses to the linear structure and to the cyclical structure when the condition was changed from free to constrained.

TABLE 15. ANALYSIS OF RESPONSE CHANGE FROM THE FREE TO THE CONSTRAINED CONDITIONS FOR LINEAR AND CYCLICAL STRUCTURES

| Free condition | Constrained condition for linear | | Constrained condition for cyclical | |
|---|---|---|---|---|
| | Stringer and Other | Bracketer | Stringer and Other | Bracketer |
| Bracketer | 3 A | 22 B | 3 A | 34 B |
| Stringer and Other | 16 C | 19 D | 8 C | 15 D |
| | $X^2 = 10.22$, $p < .01$ at df = 1 | | $X^2 = 6.72$, $p < .01$ at df = 1 | |

The above finding was further examined with relation to the Siegel Test scores. In cells B and C, Table 16, are frequencies of high-scoring subjects on the Siegel Test who did <u>not</u> change between the free and constrained conditions. Interest centers on cells A and D, frequencies of subjects who did change, cell A containing those subjects who changed from Bracketer to Stringer and Other, and cell D being whose who changed from Stringer and Other to Bracketer. The McNemar Test for the Significance of Change applied separately to high Siegel score subjects indicates a significant change ($p < .01$) from the free to the constrained condition; however, applied to low Siegel score subjects the test fails to indicate a significant change ($p < .30$).*

TABLE 16. ANALYSIS OF RESPONSE CHANGE FROM FREE TO CONSTRAINED CONDITIONS (LINEAR) FOR HIGH AND LOW SIEGEL SCORE SUBJECTS

| Free condition for linear | Constrained condition for linear | | | |
|---|---|---|---|---|
| | High Siegel subjects | | Low Siegel subjects | |
| | Stringer and Other | Bracketer | Stringer and Other | Bracketer |
| Bracketer | 1 A | 11 B | 2 | 11 |
| Stringer and Other | 5 C | 13 D | 11 | 6 |
| | $X^2 = 8.64$, $p < .01$ at df = 1 | | $X^2 = 1.12$, $p < .30$ at df = 1 | |

In Table 17 are frequency data for the cyclical structure. Again, the frequencies are tabulated to show change from free to constrained conditions in relation to Siegel scores. And again, using the McNemar Test, the data for high Siegel score subjects indicate a significant change ($p < .05$), while those for low Siegel score subjects fail to indicate a significant change ($p < .20$).* The predominant direction of change for both Siegel groups was from Stringer to Bracketer.

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*Because expected frequencies were < 5 in some cells the computations were recomputed using the Binomial Test (suggested by Siegel 33:66-67). None of the above relations was changed.

TABLE 17. ANALYSIS OF RESPONSE CHANGE FROM FREE TO CONSTRAINED CONDITIONS (CYCLICAL) FOR HIGH AND LOW SIEGEL SCORE SUBJECTS

| Free condition for cyclical | Constrained condition for cyclical | | | |
|---|---|---|---|---|
| | High Siegel subjects | | Low Siegel subjects | |
| | Stringer and Other | Bracketer | Stringer and Other | Bracketer |
| Bracketer | 1 | 17 | 2 | 17 |
| Stringer and Other | 4 | 8 | 4 | 7 |

| | High Siegel subjects | Low Siegel subjects |
|---|---|---|
| | $X^2 = 4.00$, $p < .05$ at df = 1 | $X^2 = 1.77$, $p < .20$ at df = 1 |

The change in response pattern for the hierarchical structure is shown in Table 18. Tabulations are by the hierarchical level (A to D) of the subject's first choice. (See Figure 8 for identification of levels A to D.) The largest observed change was from a predominance of A-level first choices for the free condition to a slight preference for B-level first choices for the constrained condition.

TABLE 18. COMPARISON OF FREQUENCIES OF FIRST-CHOICE RESPONSES TO DIFFERENT LEVELS OF THE HIERARCHICAL STRUCTURE FOR THE FREE AND CONSTRAINED CONDITIONS

| Condition | Hierarchical level* of first choice | | |
|---|---|---|---|
| | A | B | C, D, and Other |
| Free | 34 | 14 | 12 |
| Constrained | 22 | 24 | 14 |

*See Figure 8.

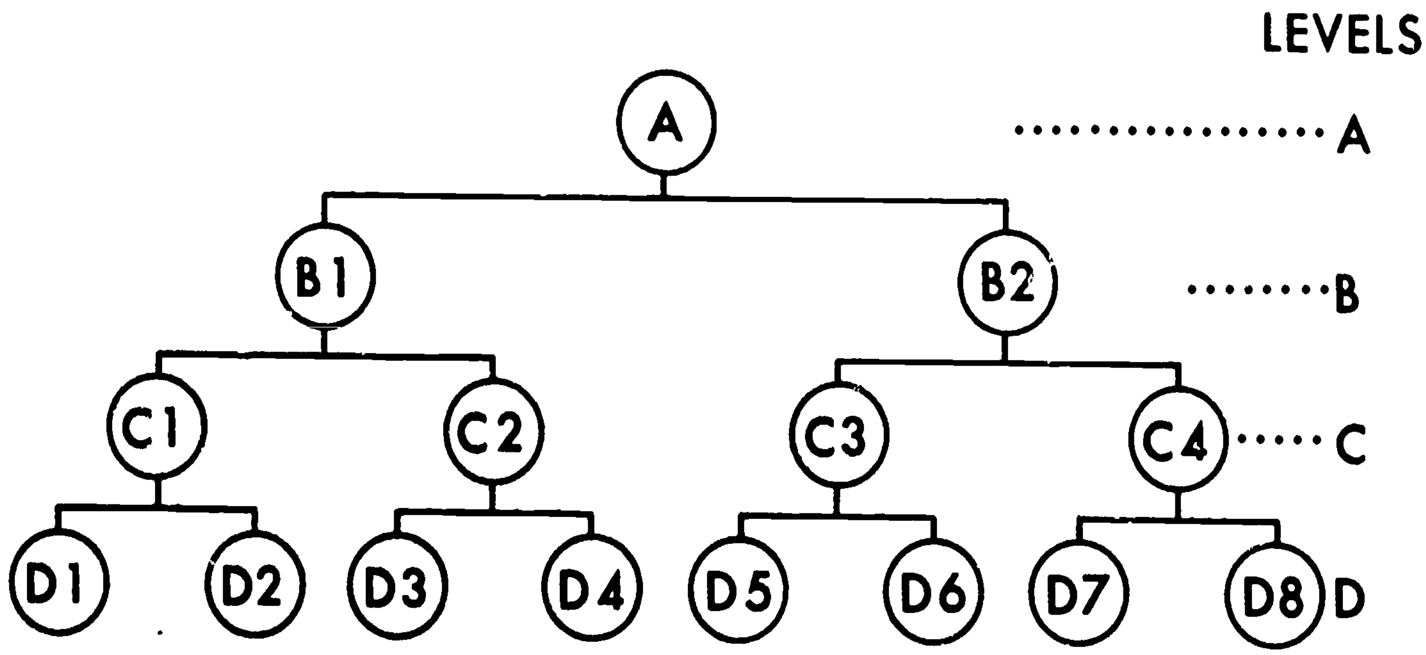


Figure 8. Hierarchical Structure Labelled by Level and Element for Identification Purposes in Analysis and Discussion

The McNemar Test of the Significance of Change was applied to the data, Table 19, and indicated that subjects showed a significant tendency to change response to the hierarchical structure when the condition was changed from free to constrained.

TABLE 19. ANALYSIS OF RESPONSE CHANGE FROM FREE TO CONSTRAINED CONDITIONS FOR HIERARCHICAL STRUCTURE

| Free condition, level of first choice | Constrained condition, level of first choice | |
|---|---|---|
| | B or Other | A |
| A | 13 | 21 |
| B or Other | 25 | 1 |

$X^2 = 8.64$, $p < .01$ at $df = 1$

Examination of these differences in relation to Siegel scores yields the data in Table 20. McNemar Tests show that high Siegel score subjects changed responses to a significant degree ($p < .05$), while low Siegel score subjects did not ($p < .10$). However, the two probabilities

are much closer together than those obtained for the linear and cyclical structures.

TABLE 20. ANALYSIS OF RESPONSE CHANGE FROM FREE TO CONSTRAINED CONDITIONS (HIERARCHICAL) FOR HIGH AND LOW SIEGEL SCORE SUBJECTS

| Free condition, level of first choice | Constrained condition, level of first choice | | | |
|---|---|---|---|---|
| | High Siegel subjects | | Low Siegel subjects | |
| | B or Other | A | B or Other | A |
| A | 6 | 11 | 7 | 10 |
| B or Other | 13 | 0 | 12 | 1 |
| | $X^2 = 4.16$, $p < .05$ at df = 1 | | $X^2 = 3.12$, $p < .10$ at df = 1 | |

A perhaps more interesting comparison of responses to the hierarchical structure in relation to Siegel scores was the Chi-square analysis, Table 21. Six patterns of responses were identified under the constrained condition by using both the first and second choices, A and B2, B2 and C4, etc. (See Figure 8.) For the high Siegel subjects response frequencies differed from that expected (five) for the six patterns by an amount significantly exceeding chance ($p < .02$). However, for the low Siegel subjects response frequencies failed to differ from that expected by chance.

Response patterns, such as Stringer and Bracketer, made to linear and cyclical structures are not patterns which can be readily identified in responses to hierarchical structures. As a consequence, comparisons of subjects' responses across several structures involve at least two category sets. A comparison of responses to the linear and hierarchical structures under the constrained condition is shown in Table 22. A Chi-square test applied to these data shows them to be associated at a significant probability level ($p < .001$).* Those subjects who responded as Bracketers to the linear structure tended to make first choices at the "B" level of the hierarchy (typically B2, see Figure 8), while subjects with other response patterns to the linear structure tended to make "A" level first choices in the hierarchy.

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*At df $> 1$ the number of cells with theoretical frequencies $< 5$ should not exceed 20% of the cells (Siegel 33:110). This condition has been met.

TABLE 21. ANALYSIS OF RESPONSE PATTERNS TO THE HIERARCHICAL STRUCTURE (CONSTRAINED CONDITION) BY HIGH AND LOW SIEGEL SCORING SUBJECTS

| Siegel scores | Pattern of first two choices | | | | | | |
|---|---|---|---|---|---|---|---|
| | AB2 | A Other | B2 C4 | B Other | D2 D4 | Other | |
| High | 5<br>10 | 5<br>1 | 5<br>7 | 5<br>8 | 5<br>3 | 5<br>1 | 30 |
| | Chi-square = 14.80, $p < .02$ at 5df | | | | | | |
| Low | 5<br>5 | 5<br>6 | 5<br>3 | 5<br>6 | 5<br>7 | 5<br>3 | 30 |
| | Chi-square = 2.80, $p < .80$ at 5df | | | | | | |

TABLE 22. ANALYSIS OF THE ASSOCIATION BETWEEN RESPONSES TO THE LINEAR STRUCTURE AND TO THE HIERARCHICAL STRUCTURE, BOTH UNDER THE CONSTRAINED CONDITION

| Linear structure | Hierarchical structure, level of first choice | | | |
|---|---|---|---|---|
| | A | B | C and D | |
| Bracketer | 15.0<br>8 | 16.4<br>22 | 9.6<br>11 | 41 |
| Other | 7.0<br>14 | 7.6<br>2 | 4.4<br>3 | 19 |
| | 22 | 24 | 14 | 60 |

Chi-square = 16.93, $p < .001$ at 2df

## Method C

Subjects were given the task of finding out about an entire iconic knowledge structure rather than about one element within the structure. To this end they were to choose the optimum order of encounter for all the elements in an entire structure. Structures were depicted on response sheets, as in Figure 7, except that all locations for elements were empty; no nonsense names nor question marks were employed. Subjects were to number the locations in the order they would like to encounter the elements so as to obtain the best understanding of the whole structure. Subjects were the same as for Method B.

## Results C

The change of response pattern from tasks A and B to the present task cannot be directly assessed because of differences in one or more of the response categories. For linear and cyclical structures the Bracketer pattern, appropriate for bracketing the one unknown location in the previous tasks, is not present in Method C responses for finding out about all the elements in the entire structure. Stringer and Extremist patterns are found for the linear structure and Stringer and Halver for the cyclical structure (see Figure 9 for definitions of these patterns).

In Table 23 are response patterns for both linear and cyclical structures in relation to the prior categorizations of learners into

TABLE 23. COMPARISON OF RESPONSE FREQUENCIES TO THE ENTIRE LINEAR AND CYCLICAL STRUCTURES BY HIGH AND LOW SIEGEL SCORING SUBJECTS

| Siegel scores | Linear | | | Cyclical | | |
|---|---|---|---|---|---|---|
| | Stringer | Extremist | Other | Stringer | Halver | Other |
| High | 18 | 10 | 2 | 21 | 3 | 6 |
| Low | 11 | 11 | 8 | 13 | 10 | 7 |

high and low Siegel scorers. Chi-square tests of the data do not reveal a significant association for either the linear data or the cyclical data (both $p < .10$). However, Chi-square One-Sample Tests, Table 24, reveal that the responses of high Siegel subjects differed significantly in frequency across the three patterns for the linear structure ($p < .01$)

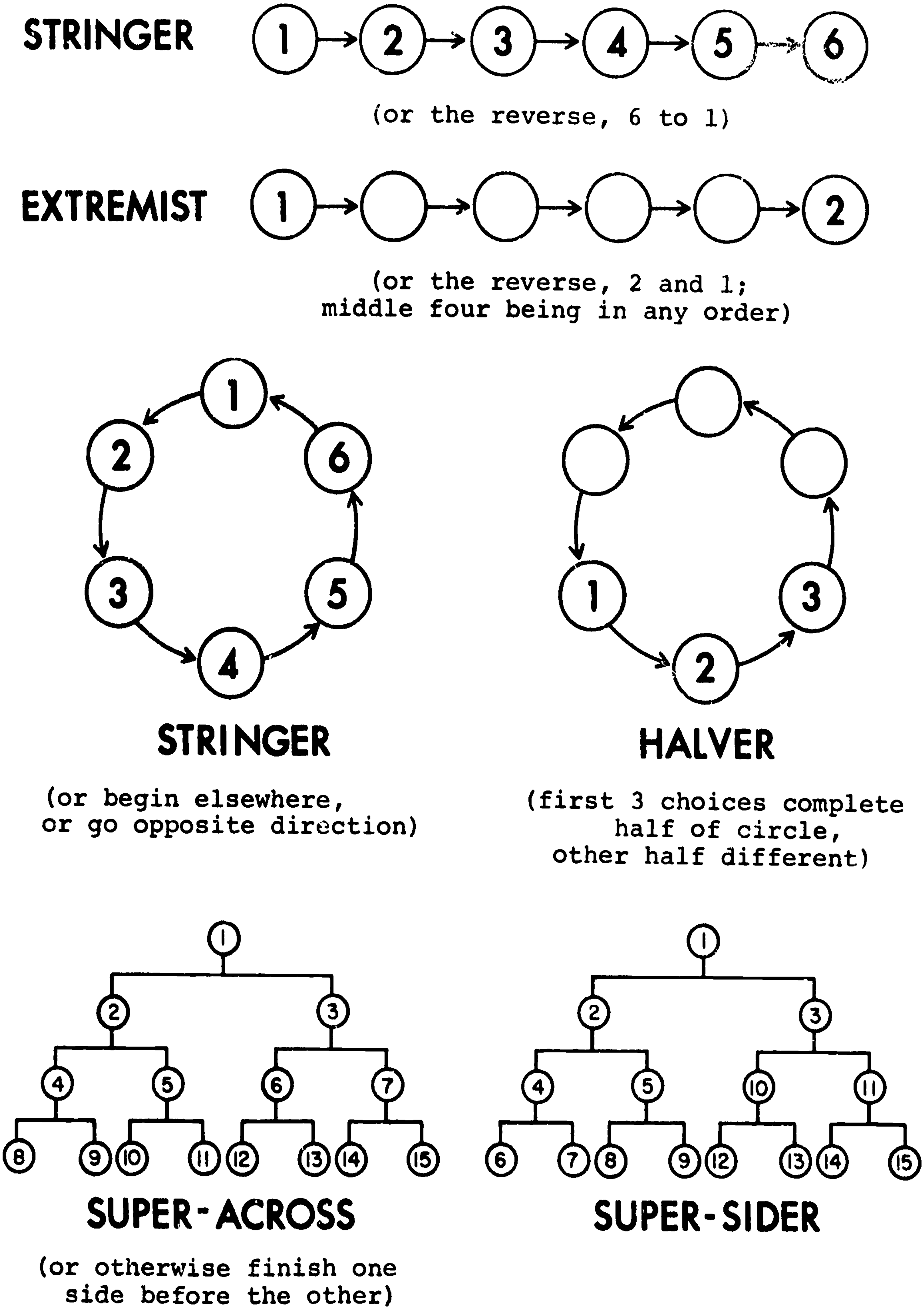



Figure 9. Response Patterns for Whole Iconic Structures, i.e., Temporal Order of Encounter of Elements Preferred by Subjects for the Purpose of Finding Out About all Elements in an Entire Structure

TABLE 24. ANALYSIS OF RESPONSE TO ENTIRE LINEAR AND CYCLICAL STRUCTURES BY HIGH AND LOW SIEGEL SCORING SUBJECTS

| Siegel scores | Linear | | | Cyclical | | |
|---|---|---|---|---|---|---|
| | Stringer | Extremist | Other | Stringer | Halver | Other |
| High | $\underline{10}$ 18 | $\underline{10}$ 10 | $\underline{10}$ 2 | $\underline{10}$ 21 | $\underline{10}$ 3 | $\underline{10}$ 6 |
| | Chi-square = 12.80 $p < .01$ @ 2df | | | Chi-square = 18.60 $p < .001$ @ 2df | | |
| Low | $\underline{10}$ 11 | $\underline{10}$ 11 | $\underline{10}$ 8 | $\underline{10}$ 13 | $\underline{10}$ 10 | $\underline{10}$ 7 |
| | Chi-square = 0.60 $p < .80$ @ 2df | | | Chi-square = 1.80 $p < .50$ @ 2df | | |

and for the cyclical structure ($p < .001$). In contrast, responses by low Siegel subjects did not differ significantly across the three patterns for the linear structure ($p < .80$) or for the cyclical structure ($p < .50$).

Predominant response patterns to the whole hierarchy were as shown in Figure 9. There were 33 Super-across responses and 8 Super-sider responses, which combined to account for 2/3 of the total responses. Other patterns were identified but they occurred too infrequently for consideration. None of the patterns was differentially associated with Siegel Test scores.

## Findings and Discussion

The data support some tentative answers to the four research questions noted earlier.

1. Is there a correlation between subjects' responses to iconic knowledge structures and their responses to standard cognitive measures?

There was evidenced a tendency for high Siegel score subjects to respond differently from low Siegel score subjects. High Siegel subjects made significant changes from the free to the constrained conditions, while the low Siegel subjects did not. Perhaps, high Siegel subjects were

more adaptable to task changes or were more challenged by the additional constraints, or perhaps they better understood the task. These data (Methods A and B), and the Method C data as well, suggest that high Siegel subjects, under some conditions, showed marked tendencies to select one or two response patterns over others, while low Siegel subjects tended to distribute their selections somewhat uniformly across all patterns.

It is difficult to predict what pattern a concept-seeker (high Siegel score) would be expected to follow. If concept-seeking is interpreted as some consistent behavior pattern across tasks, it was not observed in this study. Whereas if concept-seeking implies seeking the "concept" or problem solution implicit in and particular to each task, then such behavior was observed, and clearly was that of the subjects with high Siegel scores.

2. Will the responses to iconic structures by another sample of graduate education students differ from those obtained for comparable tasks in Study 2?

No, responses by one group of graduate education students did not differ, for the same tasks, from the responses of a previous group of such students.

3. Will the addition of constraints to the task of choosing temporal order of encounter alter the pattern of responses?

Yes, the addition of constraints did significantly alter response patterns, particularly for high Siegel subjects.

4. When subjects are given the task of finding out about all elements in an entire structure instead of about one specified element (as in Study 2) will their choices of temporal order of encounter follow identifiable patterns?

Yes, responses to entire structures were categorizable, but over half the responses to the entire hierarchical structure were of one type.

# CHAPTER V

## REPORT OF STUDY 4

### Purpose

The three variables (knowledge structure, message structure, and learner structure), having been given preliminary tests in related Studies 1 to 3, were next examined in a study in which all three variables were considered together but with somewhat different tasks and methods. Prior tasks were administered to groups; Study 4 tasks were administered to individuals, primarily so as to examine a subject's behavior in greater depth and for a longer time. Prior tasks were with empty structures or with nonsense names, while Study 4 introduced new and more realistic learning tasks.

The study of learner structure, previously limited to one test, was extended to three others: Similarities Subtest of the Wechsler (42), Closure Flexibility (38), and Closure Speed (39). The Similarities Subtest of the Wechsler was chosen as a quick verbal intelligence measure, while the closure tests were chosen as non-verbal measures. It was expected that these three tests might measure somewhat stable response predispositions with regard to verbal elements in non-verbal (iconic) knowledge structures.

The research questions were as follows:

1. Would use of an iconic knowledge structure facilitate subjects' performance on a problem solving task?

2. In what ways would subjects arrange or structure a list of words for memorization purposes?

3. To what degree would subjects' scores on several standard cognitive tests correlate with their performance on the tasks indicated in 1 and 2 above?

4. Would responses to iconic structures be reliable, i.e., would responses be similar in a test-retest situation?

### Method A

Twenty subjects were chosen from the sixty in Study 3. Two groups of ten were identified as follows: (1) individuals who scored in the top half on the Siegel and Siegel Test of Educational Set (32) and also adopted "good" strategies in the linear and hierarchical structure tasks, and (2) individuals who scored in the bottom half of the Siegel Test and also adopted "poor" strategies in the linear and hierarchical structure

tasks. The evaluation of strategies used by the subjects in Study 3 was based upon a brief logical analysis of the tasks. Specifically, a "good" strategy for the linear structure (constrained task) was Bracketer, while a "poor" strategy was Stringer or Other. A "good" strategy for the hierarchical structure (constrained) was one beginning with level "B," typically B2 C4; while a "poor" strategy was one beginning with "A" or "C" or "D" levels, typically AB1 or AB2. See Figure 8 and Table 18, Study 3.

Subjects were contacted by telephone and told that they responded to the empty structures in very interesting and insightful manners and were asked if they could meet to discuss their responses to those tasks and also to try a few other tasks of a similar nature. Two experimenters were each assigned 10 subjects non-randomly so as to systematically confound subject class (Siegel score), treatment condition, and interviewer. See Appendix D for table giving subjects by class and treatment. Testing procedures included extensive instructions for each task as well as preliminary examples for practice purposes.

For the Method A task subjects were required to find the 12 relationships between the four members of a hypothetical family whose names were Fit, Gex, Jat, and Mip. The task was presented as a game consisting of a 4 x 4 matrix, Figure 10, with disks covering the 12 cells which indicated non-identity relationships. Subjects were to predict (guess, initially) what each relationship was. Beginning at any point in the matrix they were to make a prediction, then lift the appropriate disk to reveal the correct relationship. For example, Figure 11 shows the matrix after four responses have been made and the disks removed. Correct responses would have been, "Fit is Gex's son," "Gex is Fit's mother," etc. Using nonsense names eliminated relevant cues as to the sex of the individual.

There were two treatments, Structure Salient and Structure Free. The Structure Salient group was provided an empty iconic knowledge structure, such as Figure 12A, which suggested how the four family members were related. These subjects were also provided four disks labelled Fit, Gex, Jat, and Mip which they could place on the structure as an aid in discovering and recording the relationships. (Figure 12B shows the correctly filled structural aid.) Subjects were given a practice trial with an example aid but were not required to use or fill the iconic structural aid on the test trial. The thought was that the use no-use choice itself might be an important datum in distinguishing types of learners.

The Structure Free group was given no such structural aid. Both groups had paper and pencil which they could use for calculating and recording purposes.

The number of correct responses out of the 12 trials constituted the subjects' scores. Also, the time to complete the task was recorded for each subject.

| | Fit's | Gex's | Jat's | Mip's |
|---|---|---|---|---|
| Fit is | | Son | Brother | Son |
| Gex is | Mother | | Mother | Wife |
| Jat is | Sister | Daughter | | Daughter |
| Mip is | Father | Husband | Father | |

Figure 10. 4 x 4 Matrix Showing the Twelve Family Relationships Which Subjects Were to Predict

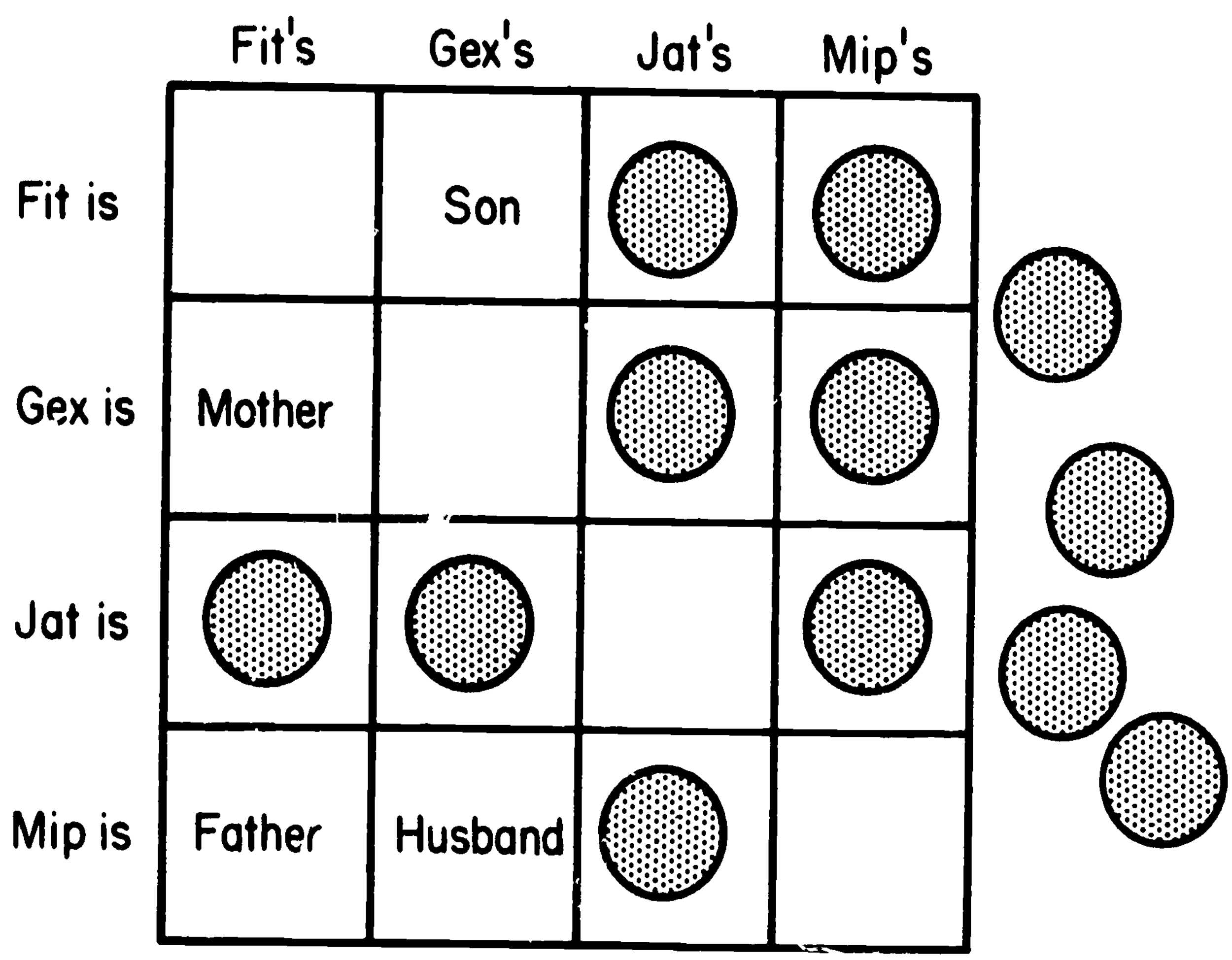



Figure 11. Family Relationship Learning Task in Progress, Four Predictions Having Been Made and Confirmed

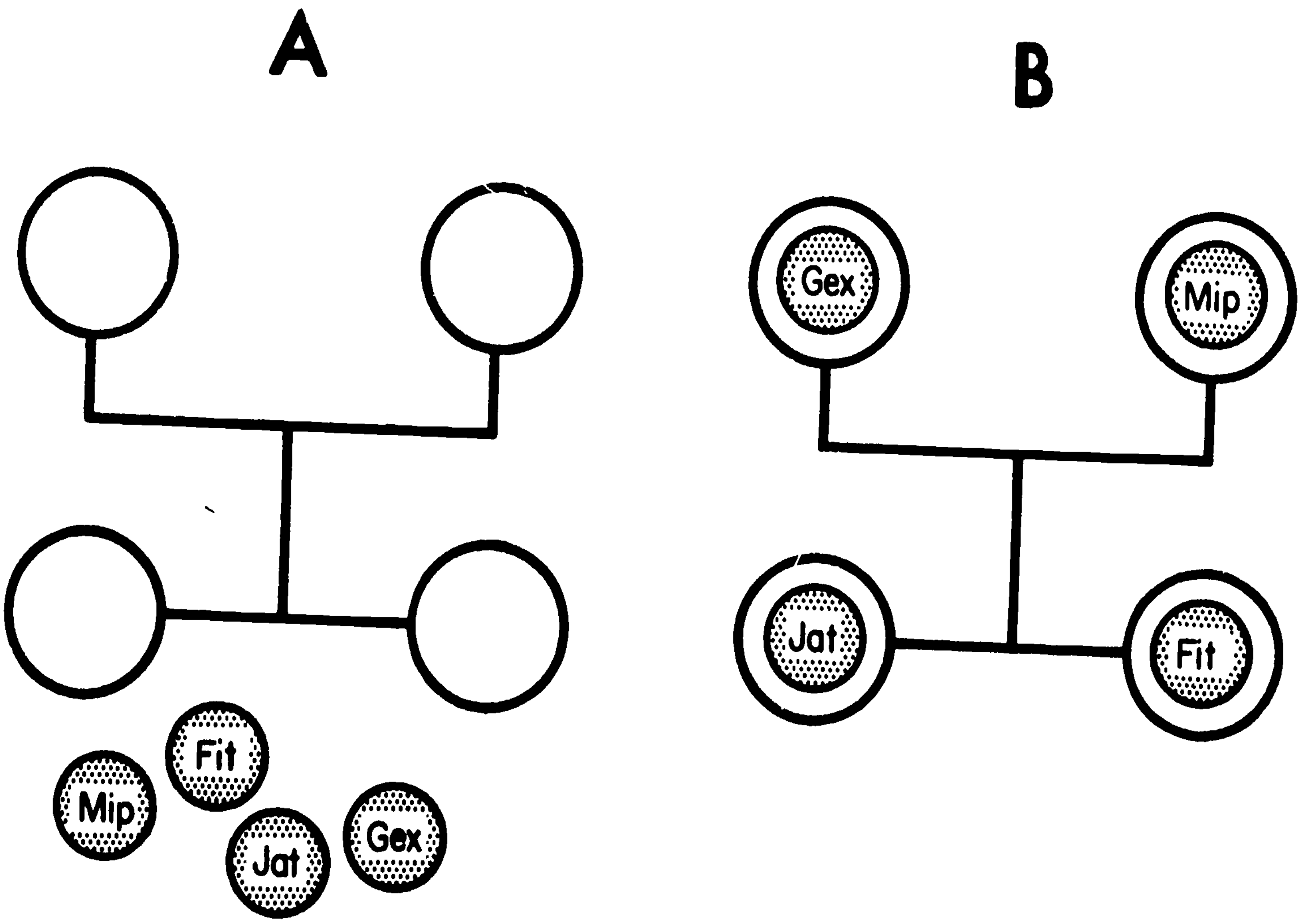



Figure 12. Iconic Structural Aid Provided to Structure Salient Treatment Group for Family Relationship Learning Task, Before Use (A) and After Use (B)

## Results A

The Structure Salient group had a slightly higher mean score (larger number of correct predictions) than the Structure Free group but took proportionately longer to complete the task, Table 25. However, these data are questionable for the reason that not all the so-called Structure Salient group actually availed themselves of the iconic knowledge structure provided (Figure 12). Consequently, a comparison was made of the subjects within the Structure Salient group who appeared to make use of the structure and those who did not. These data, Table 26, suggest that the subjects who used the structure achieved a slightly higher mean score and took a slightly shorter time. However, these data are not as reliable as would be desired because there was no way to determine accurately the degree of use made of the structure. The criterion for making use of the structure was "at least 3 of 4 'men' placed on the structure by the 5th prediction." However, some

TABLE 25. COMPARISON OF MEAN SCORES AND MEAN TIMES TO COMPLETE TASK FOR TREATMENT GROUPS--STRUCTURE SALIENT AND STRUCTURE FREE

| Treatment | Mean score (number correct) | Mean time to complete (min.) |
|---|---|---|
| Structure Salient | 7.2 | 6.5 |
| Structure Free | 6.2 | 5.5 |

TABLE 26. COMPARISON OF MEAN SCORES AND MEAN TIMES TO COMPLETE TASK FOR THOSE SUBJECTS (STRUCTURE SALIENT TREATMENT) WHO USED AND DID NOT USE THE STRUCTURAL AID

| Use of structure | Mean score (number correct) | Mean time to complete (min.) |
|---|---|---|
| Yes | 7.6 | 5.9 |
| No | 6.8 | 7.2 |

subjects put no "men" on the structure overtly but may have done so covertly.

Did those Structure Salient treatment subjects who appeared to use the structural aid differ on standard measures from those who appeared not to use it? As shown in Table 27, the differences were not large and did not consistently favor either group.

TABLE 27. COMPARISON OF STANDARD TEST MEANS FOR SUBJECTS WHO DID AND DID NOT USE THE STRUCTURAL AID

| Use of structure | Siegel | Similarities | Closure speed | Closure flexibility |
|---|---|---|---|---|
| Yes | 17.2 | 17.4 | 17.2 | 62.0 |
| No | 17.0 | 16.8 | 14.8 | 68.0 |

Given free choice as to the order of encountering each relationship in the 4 x 4 matrix, subjects evidenced two apparent patterns, a

Reversal pattern and a Progressive pattern. The Reversal pattern can be seen in the top of Figure 11. Here, a prediction that Fit is Gex's son is followed by the reverse, that Gex is Fit's mother (or father). As shown in Table 28, the Reversal pattern was the most frequently used by both experimental groups but was most strongly favored by the Structure Free group. In one sense this pattern can be said to indicate productive use of another type of knowledge structure, namely a 4 x 4 matrix.

TABLE 28. COMPARISON OF NUMBER OF USES OF TWO RELATIONSHIP LEARNING STRATEGIES BY TREATMENT GROUPS--STRUCTURE SALIENT AND STRUCTURE FREE

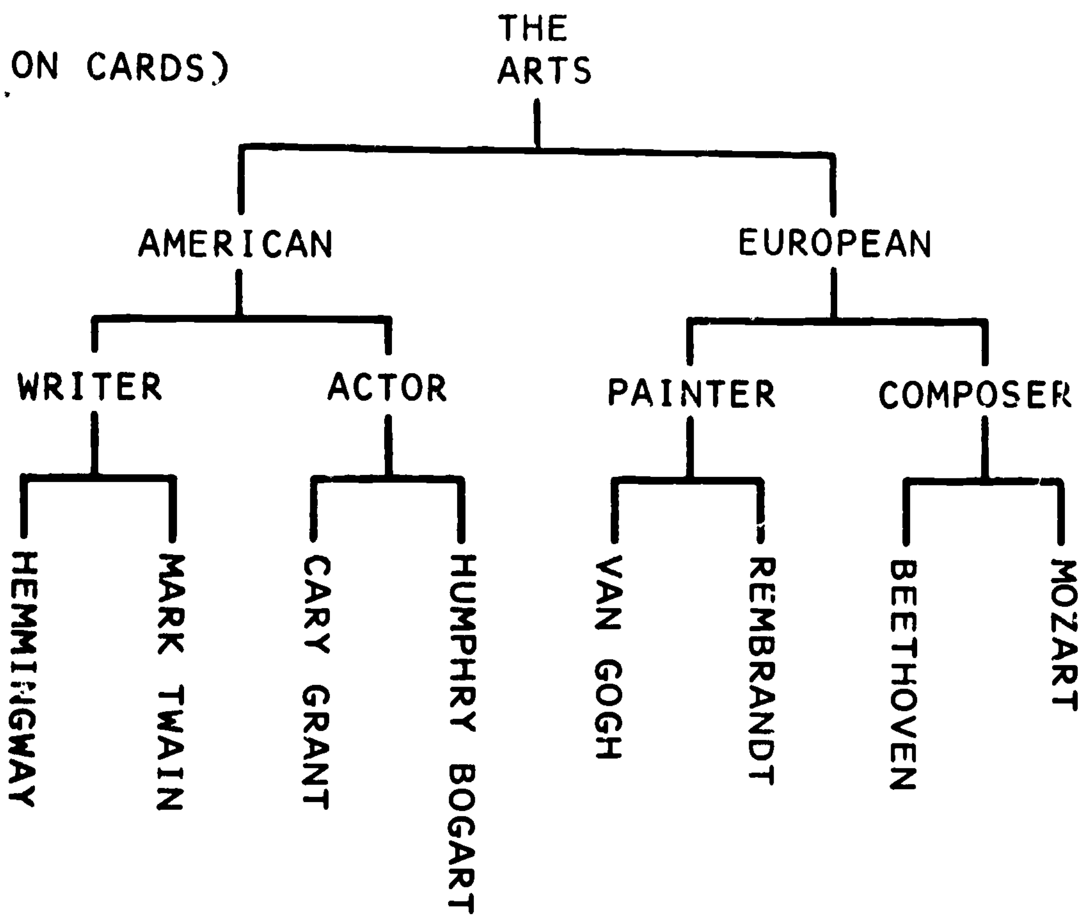
| Treatment | Relationship learning strategies | |
|---|---|---|
| | Reversal | Progressive |
| Structure Salient | 20 | 11 |
| Structure Free | 29 | 3 |

In the Progressive pattern, bottom of Figure 11, the subject moves across a line predicting all of one person's relationships, for example, Mip's relationship to Fit, then to Gex, etc. This pattern occurred most frequently with the Structure Salient group, and of the eleven uses of the pattern nine were by the individuals who appeared to actually employ the iconic structural aid.

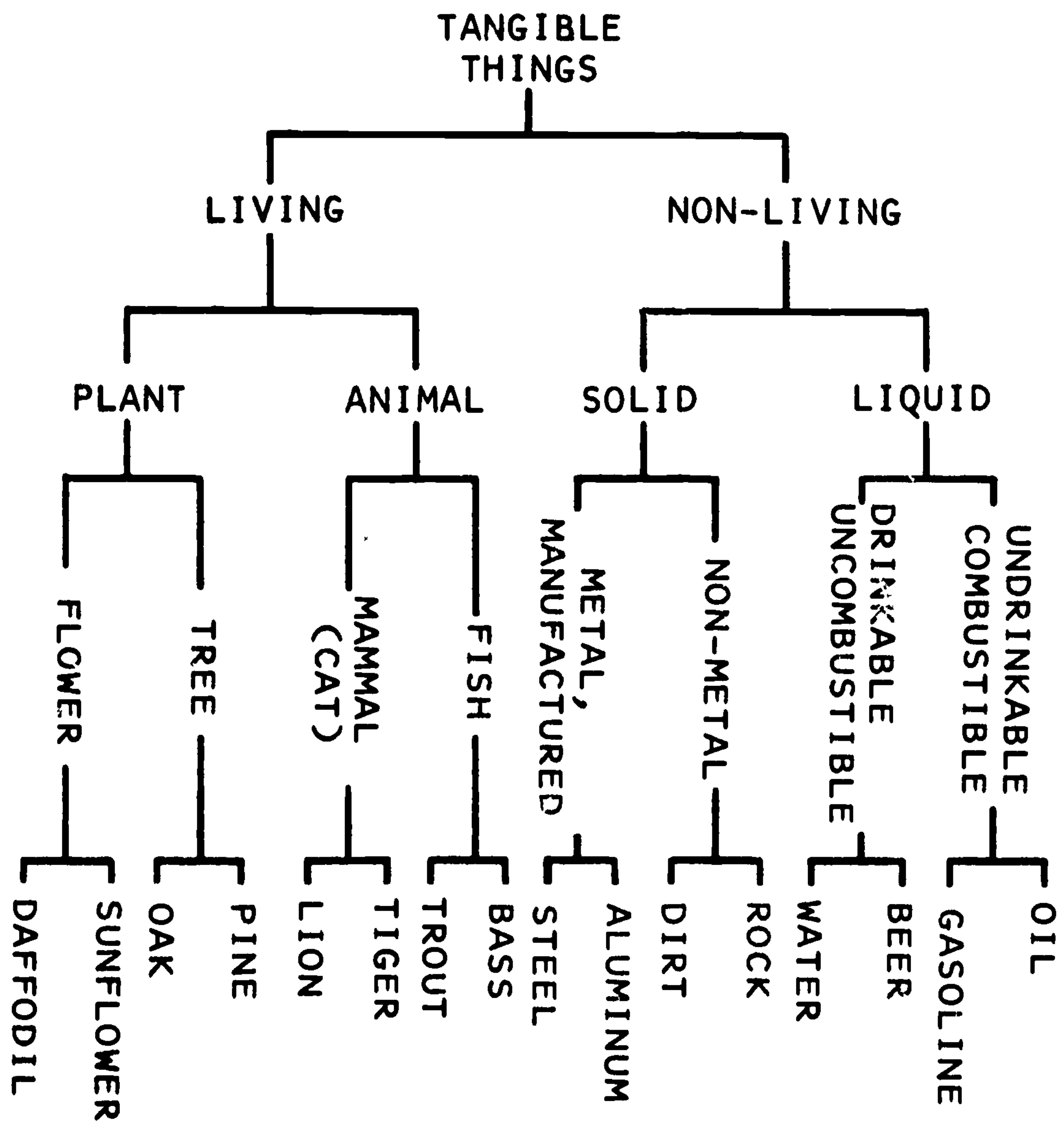
## Method B

The same subjects were employed as for Method A, but the task was quite different. Subjects were given a pile of small white cards, each card bearing a word. The subject's task was to arrange the cards in the order he would prefer they be presented to him for memorization purposes. Subjects repeated this sorting and ordering process for three different sets of cards. Although the subject was not so informed, the cards in each pile bore a hierarchical relation to each other. See Figure 13, pages 59 and 60, for the three hierarchical groupings of words. Hierarchy #1 was judged to be of low-difficulty (four levels instead of five); Hierarchy #2 was judged to be of medium-difficulty (concrete items); Hierarchy #3 was judged to be of high-difficulty (abstract items). Another aspect contributing to the differences in task difficulty was that subjects were given cards for all 15 elements in Hierarchy #1, whereas the 16 cards for Hierarchies 2 and 3 included only the names of the most subordinate level elements. As a consequence, subjects were provided the superordinate categories for grouping Hierarchy #1 elements, but they were left to contrive their own superordinate categories for

#1 LOW-DIFFICULTY HIERARCHY
(ALL 15 ELEMENTS ON CARDS)




#2 MEDIUM-DIFFICULTY HIERARCHY
(BOTTOM 16 ELEMENTS ON CARDS)



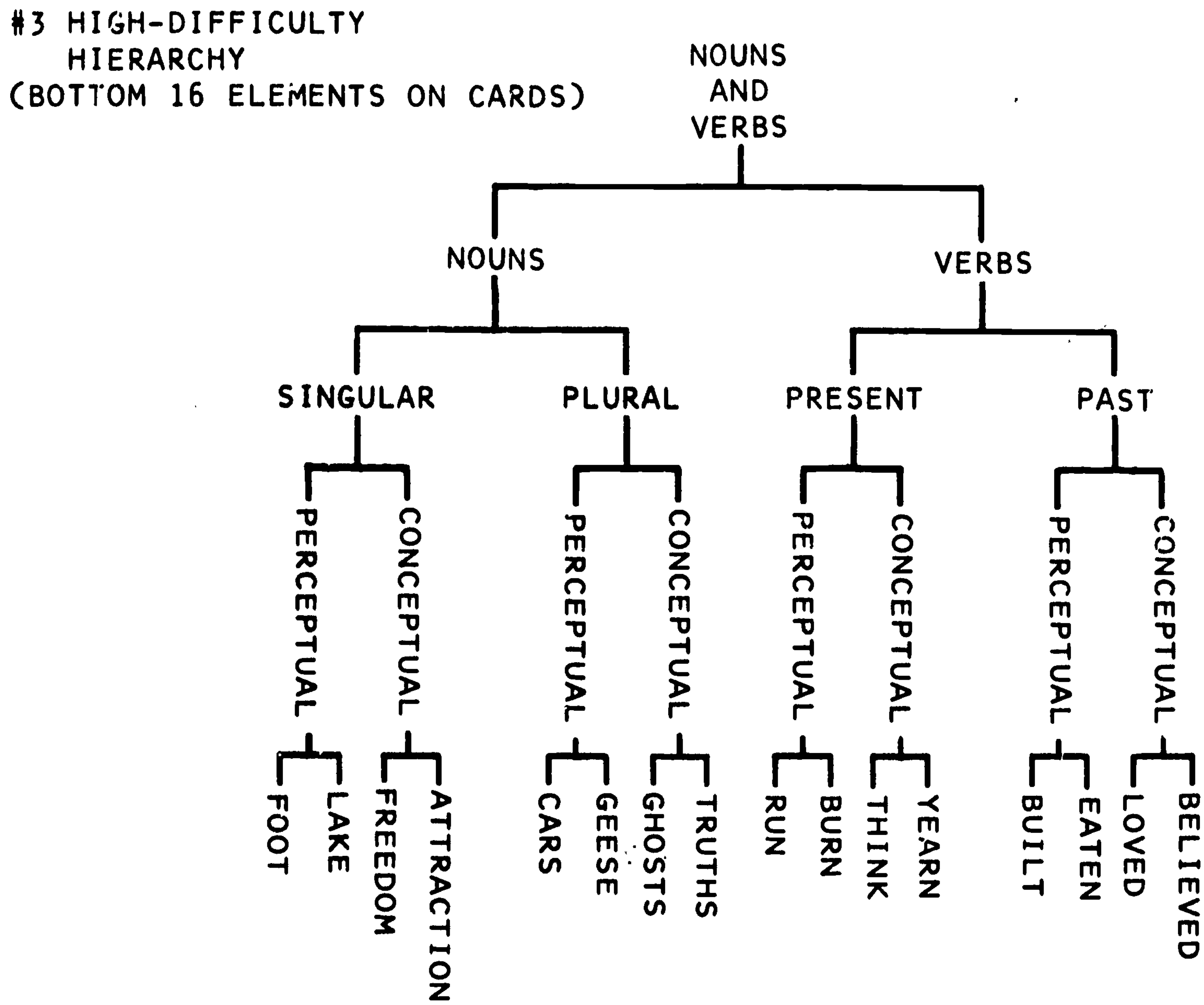



Figure 13. Hierarchical Groupings #1 - #3 Used in Card Ordering Task

grouping Hierarchy 2 and Hierarchy 3 elements. The independent variable was the temporal order in which the sets of cards were presented to the subject, low to high difficulty or high to low difficulty. The Structure Salient group were presented the groups of cards in low to high order, while the Structure Free group were presented groups of cards in high to low order.

Subjects were allowed as much time as desired for the task, and when they had completed it they were asked to identify the basis for their arrangement of the cards in each pile, identifying sub-groupings, associations between adjacent cards, etc.

## Results B

Hierarchy #1 (Figure 13) permitted analysis of the temporal ordering of cards because all levels of the hierarchy were included. A plausible prediction would be that the more superordinate the element in the hierarchy, the earlier it would occur in a subject's temporal ordering. More specifically, the following could be predicted relative to Hierarchy #1:

1. The Arts will occur before American or European
2. American will occur before Writer or Actor
3. European will occur before Painter or Composer
4. Writer will occur before Twain or Hemmingway
5. Actor will occur before Bogart or Grant
6. Painter will occur before Van Gogh or Rembrandt
7. Composer will occur before Mozart or Beethoven

To test these predictions each subject's ordering of the elements was numbered from 1 to 15, first to last. These temporal orderings were tabulated by element and averaged, yielding values representing mean temporal order. Testing of each prediction was by inspection. The mean ordering for The Arts should have a lower numerical value (occur earlier) than American or European (prediction #1), etc. Twelve of the 14 predictions tested in this direct way were supported. Discrepancies were with reference to predictions #2 and #3, Actor being placed before American, and Composer before European. These discrepancies may be ascribed as much to subjects' knowledge about the arts as to their hierarchical ordering tendencies.

In general, subjects appeared to prefer a hierarchical ordering of elements to be learned, particularly within a small grouping such as: American, Writer, Hemmingway, Twain.

Hierarchy #2 (medium-difficulty) data were judged most suitable for treatment comparisons, because for the Structure Salient subjects, this task was immediately preceded by the low-difficulty task (Hierarchy #1), whereas for the Structure Free subjects, this task was preceded by the high-difficulty task (Hierarchy #3). Hierarchy #2 data consisted of the ordering of the 16 elements by each subject and the several groupings into which he had subdivided them. Two schemes were tested for categorizing the reported groupings, one with reference to the experimenters' preconceived groupings (based on hierarchy #2, Figure 13) and one which employed no preconceived groupings. In either case, high scores were assigned to large groupings (more superordinate categories) and low scores to small groupings (more subordinate categories). For example, a grouping including lion, tiger, trout, and bass was scored higher than a group of just trout and bass. Typically, a score for a group was the square of the number of elements in it. See Appendix D for further details regarding categorizing and scoring.

The mean scores by treatment are shown in Table 29 for both scoring methods. The means were lower for the judging scheme using the experimenters' categories, because groupings which did not correspond to these categories were not counted. With reference to the experimenters' categories the Structure Salient group obtained the highest mean score, whereas with reference to the subjects' categories the Structure Free group obtained the highest mean score. Some of the subjects' categories, however, were arbitrary and non-hierarchical, an aspect that the latter categorizing and scoring scheme ignored.

TABLE 29. COMPARISON OF MEAN SCORES BY TREATMENTS FOR TWO SCORING METHODS--ADHERING TO EXPERIMENTERS' PRECONCEIVED CATEGORIES, OR ACCEPTING SUBJECTS' SPONTANEOUS CATEGORIES

| Treatment | Method for scoring responses | |
|---|---|---|
| | Experimenters' categories | Subjects' categories |
| Structure Salient | 31.4 | 49.2 |
| Structure Free | 24.7 | 65.4 |

Another rationale for the analysis of these data was that of the number of different sizes of groupings formed. For example, some subjects formed eight groups of two (one size), while others formed two groups of two, one group of three, and two groups of four (three sizes). In Table 30 is a tabulation of the number of subjects who formed one-or-two different sizes of groupings as compared to those who formed three

TABLE 30. ANALYSIS OF NUMBER OF SUBJECTS IN THE TWO TREATMENT GROUPS WHO FORMED GROUPINGS OF DIFFERENT SIZES FROM HIERARCHY #2 CARDS

| Treatment | Number of different sizes of groupings | |
|---|---|---|
| | 1 or 2 | 3 or more |
| Structure Salient | 4 A | 6 B |
| Structure Free | 9 C | 1 D |

P = .10 (where B = 6 and D = 1)*

*Siegel, 33:258.

or more different sizes. The Structure Salient subjects formed a greater number of varied size groups (3 or more sizes), while the Structure Free subjects formed a greater number of the same size groups (1 or 2 sizes). A Fisher Test of Exact Probability shows that there was not a significant difference ($p = < .10$) between the treatment groups with reference to the number of different sizes of card groupings formed. A Chi-square test was not used because two of the expected frequencies $< 5$. (33:110)

An attempt was made to assess the degree of the relationship between scores on the experimental tasks, Methods A and B, and scores on the standard measures. See Appendix D for raw scores and rank orders. A Spearman Rank Correlation Coefficient was computed for each pair of scores as shown in Table 31. Scores on the Family Relationship Learning task were positively correlated ($r = .50$ for Number Correct and .49 for Time to Complete) with Closure Flexibility scores. Time to complete was also positively correlated ($r = .55$) with Closure Speed. These three correlations were shown by t-test to be the only significant correlations ($p < .05$) between task scores and standard scores. Scores on the Card Ordering task (scored using subjects' categories) had a higher positive correlation ($r = .24$) with Similarities scores than with any other standard measure, but did not reach the chosen significance level.

At the close of Study 4, subjects were asked to again perform a task from Study 3. (Method C involving temporal ordering of all elements in entire structures.) They were to do this without trying to recall their prior responses. An informal comparison of responses to the entire hierarchy revealed a number of differences in particular details but only two subjects of 20 whose responses fell into different categories than before.

## Findings and Discussion

With reference to the research questions for this study several tentative statements may be made.

1. Would use of an iconic knowledge structure facilitate subjects' performance on a problem solving task?

Any affirmative answer to this question based on Study #4 would require extensive qualifying. Evidence to suggest the structure may facilitate correct responses is more supportable than is evidence to suggest that the structure may shorten the task solution time; however, Study #4 data do not make possible any reliable answer.

2. In what ways would subjects arrange or structure a list of words for memorization purposes?

TABLE 31. CORRELATIONS OF STANDARD TEST SCORES WITH TASK SCORES, STUDY 4

| | | Standard measures | | | | Family relationship task | | Card ordering task | |
|---|---|---|---|---|---|---|---|---|---|
| | | Siegel | Similar-ities | Closure speed | Closure flexi-bility | Number correct | Time to complete | Experi-menters' cate-gories | Subjects' cate-gories |
| Standard measures | Siegel | | -.09 | .15 | .35 | .33 | .34 | -.20 | -.13 |
| | Similarities | -.09 | | -.30 | -.19 | -.09 | -.11 | .18 | .24 |
| | Closure speed | .15 | -.30 | | .33 | .26 | .55 | .07 | -.35 |
| | Closure flexibility | .35 | -.19 | .33 | | .50 | .49 | .08 | -.03 |
| Family relation-ship task | Number correct | .33 | -.09 | .26 | .50 | | .55 | .21 | .11 |
| | Time to complete | .34 | -.11 | .55 | .49 | .55 | | .27 | -.14 |
| Card ordering task | Experimenters' categories | -.20 | .18 | .07 | .08 | .21 | .27 | | -.54 |
| | Subjects' categories | -.13 | .24 | -.35 | -.03 | .11 | [illegible] | [illegible] | |

It depends. Where appropriate superordinate elements are part of the list, as in Hierarchy #1, they are typically used to arrange hierarchical groupings within the list, i.e. superordinate elements preceding subordinate elements. This preference for encountering superordinate elements first is consistent with Study 3 data. In both cases the finding is associated with the order of encounter for the process of learning. Does this mean that a given new word is easier to associate with an immediately prior superordinate word than with an immediately prior subordinate one? Related evidence dealing with the process of recall is suggested in Study 5 and in the Discussion section of Chapter VII.

Where the subject must provide his own way of categorizing, the bases are more idiosyncratic and may include hierarchical, temporal, alphabetical, or arbitrary associations. Surprisingly, the only subject to use the alphabetical basis (judged to be arbitrary) for ordering all 16 elements was one who ranked among the highest on the standard tests.

3. To what degree would subjects' scores on several standard cognitive tests correlate with their performance on the tasks in this study?

Three significant positive correlations were found between standard test scores and task scores. These were between the Closure Tests (Flexibility and Speed) and certain measures from the Family Relationship Learning task.

None of the correlations between the four standard measures was significant. The highest positive correlation, .35, was between the Siegel Test and Closure Flexibility, while the highest negative correlation, -.30, was between Similarities and Closure Speed.

Two inter-task correlations were significant, .55 between the two measures (number correct and time to complete) for the Family Relationship task and -.54 between the two ways of categorizing data for the Card Ordering task, one with reference to experimenters' categories and one with reference to subjects' categories.

4. Would responses to iconic structures be reliable, i.e., would responses be similar in a test-retest situation?

Certain tasks from Study #3 were repeated with some of the same subjects who were used in Study #4. Only minor differences were observed in responses to the entire hierarchy for 18 of the 20 subjects.

## CHAPTER VI

## REPORT OF STUDY 5

### Purpose

This study was intended both to extend and refine previous work. Earlier work was extended through the use of tasks which more closely approximated classroom learning. Two tasks involved the learning of verbal elements in hierarchical iconic structures. The two questions asked were as follows:

1. Will the effect on recall be positive where the recall context is structurally the same as the learning context, and will the effect be negative where the learning and recall contexts differ structurally?

2. Will recall of elements in a hierarchy be influenced by the order of presentation--superordinate to subordinate or subordinate to superordinate?

In Study 5 earlier work on linear structures was refined through the use of meaningful elements instead of hypothetical ones. The question asked was:

3. Will subjects assigning meaningful elements to linear structures differentiate between certain types of linear structures (horizontal or vertical, with or without arrows) in a way comparable to that found in Study 1 with reference to hypothetical elements and relationships?

Study 5 represented a refinement of the learner structure variable. A different measure of general intelligence was employed (Wonderlic Personnel Test) and other measures either were retained or dropped depending on prior studies in this series. The question asked was:

4. Will responses to the learner structure measures be correlated with responses to the above tasks?

### Method A

Subjects were exposed, for 45 seconds by overhead projection, to 15 words in a hierarchy, Figure 14. They were then to recall and write as many of the words as possible in the spaces provided on a response sheet. Three different response sheets (recall contexts) constituted the treatments, which were randomly assigned to subjects. One response sheet contained a hierarchy like the learning context (#1, Figure 15)

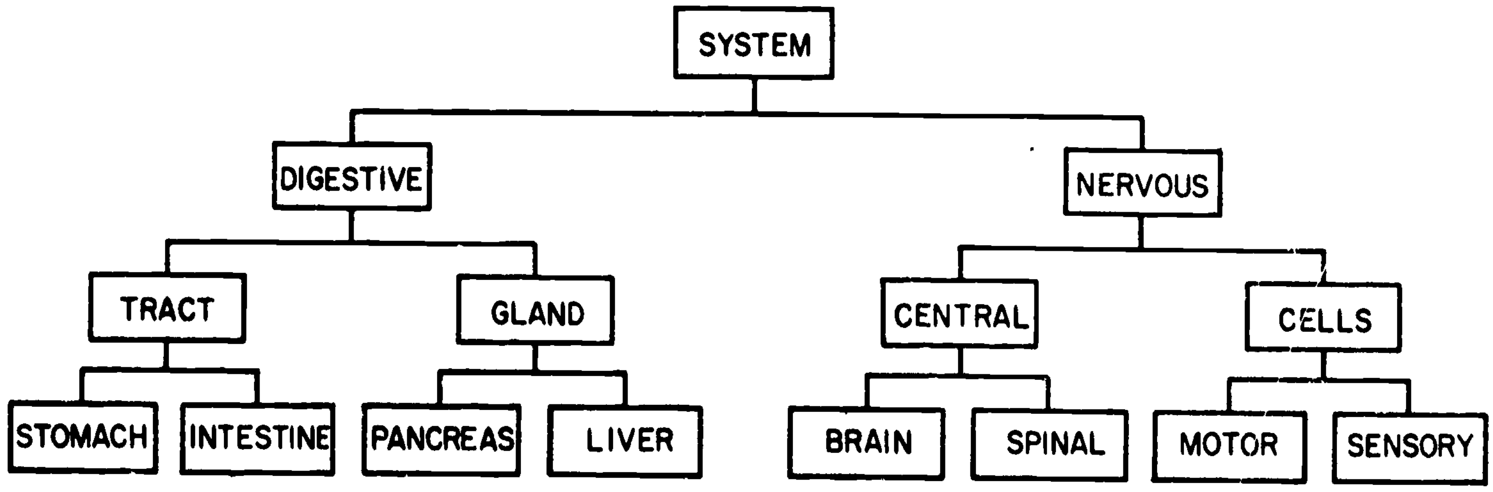



Figure 14. Elements Displayed in a Hierarchy (Learning Context) for Study 5A

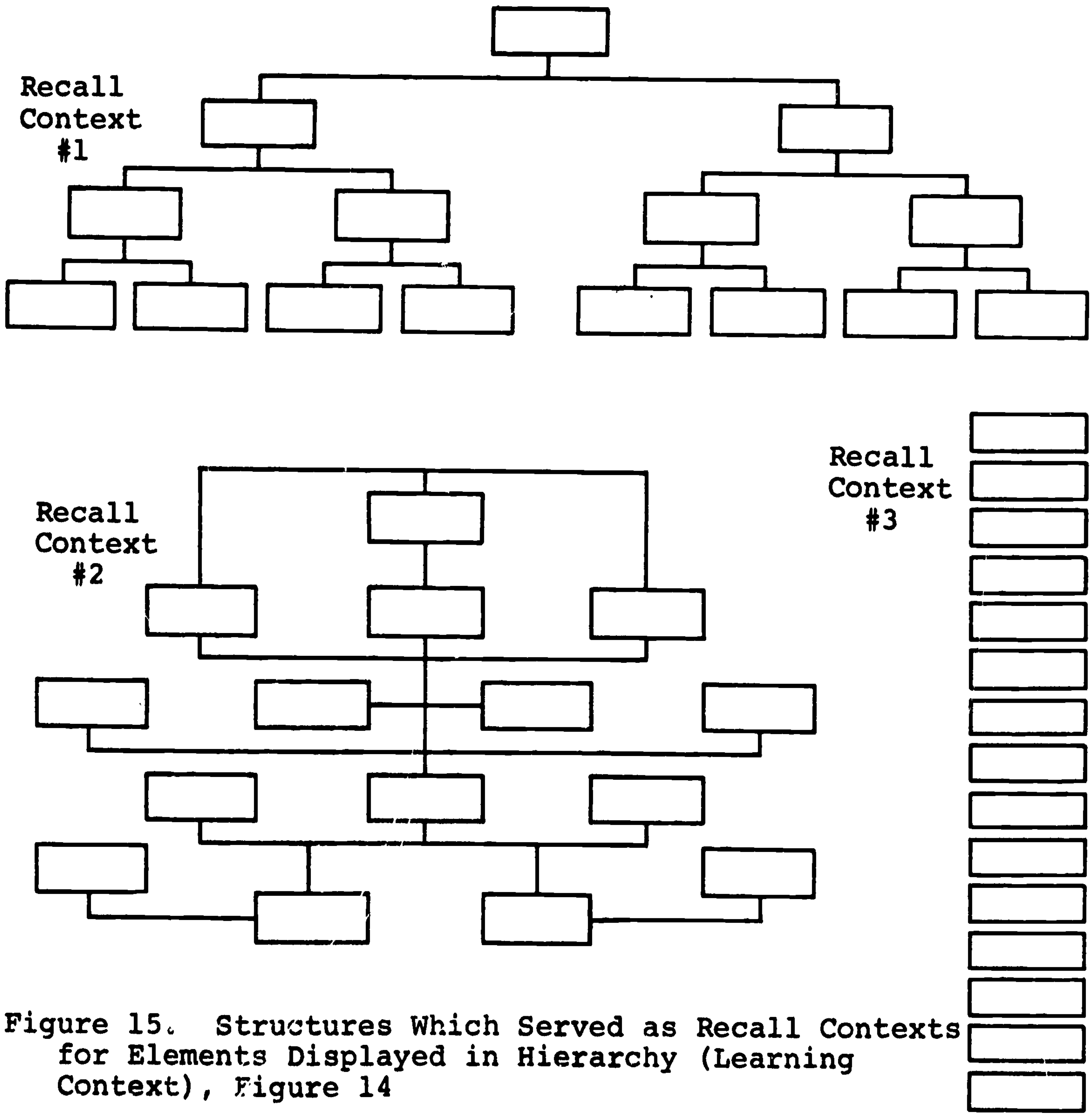



Figure 15. Structures Which Served as Recall Contexts for Elements Displayed in Hierarchy (Learning Context), Figure 14

and the other two contained structures which deviated increasingly from it (#2 and #3).

The 33 subjects were a convenience sample of graduate education students in extant classes.

## Results A

The means were in the anticipated direction, i.e., highest for the recall context which matched the learning context and decreasing as the recall contexts differed increasingly from the learning context. The respective means were 10.9, 9.4, and 9.1 of a total of 15 elements in the structure. A One-way Analysis of Variance of these data yielded an F of 1.82 at 2,30 df. (See Table 32). The differences were not significant, $p < .20$. A covariance analysis with Wonderlic scores as the covariate yielded similar results.

TABLE 32. ANALYSIS OF VARIANCE FOR TREATMENTS--RECALL CONTEXTS

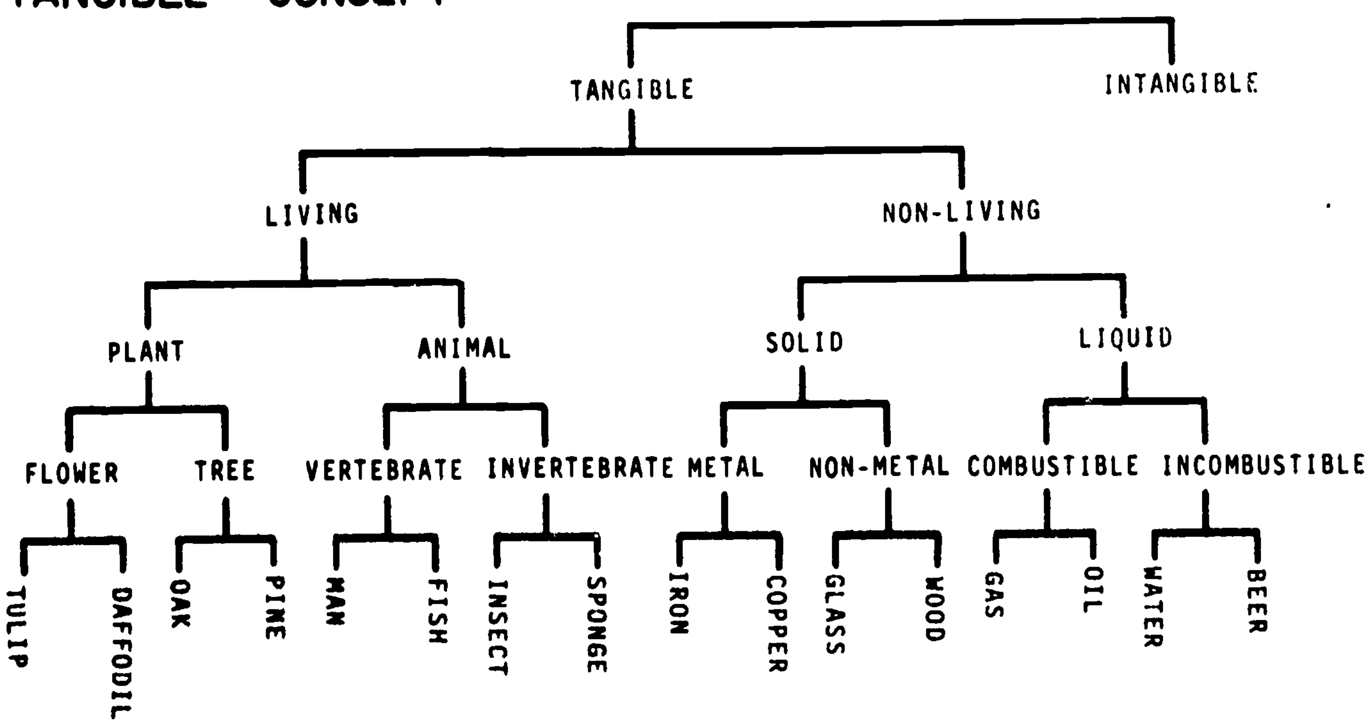
| Source of variation | SS | df | MS | F |
|---|---|---|---|---|
| Treatments (recall contexts) | 22 | 2 | 11.00 | 1.82* |
| Within | 181 | 30 | 6.03 | |
| Total | 202 | 32 | | |

*$p < .20$ at 2,30 df

## Method B

Subjects were shown by overhead projection two empty hierarchical structures. The 32 elements in each structure were revealed in a systematic order until the hierarchy was complete, Figure 16. Elements were revealed in pairs in a certain sequence--either from the top down (superordinate to subordinate) or from the bottom up (subordinate to superordinate). Each pair was displayed for three seconds before the next pair was revealed. The two orders of presentation are shown in Figure 17. The temporal order of presentation of elements constituted the treatment, being either superordinate or subordinate. It should be noted that what is called superordinate order of presentation in Study 5 is but one of several systematic patterns that could properly be called superordinate. The one chosen, Figure 17, corresponds to the Super-sider

"TANGIBLE" CONCEPT




"WORD" CONCEPT

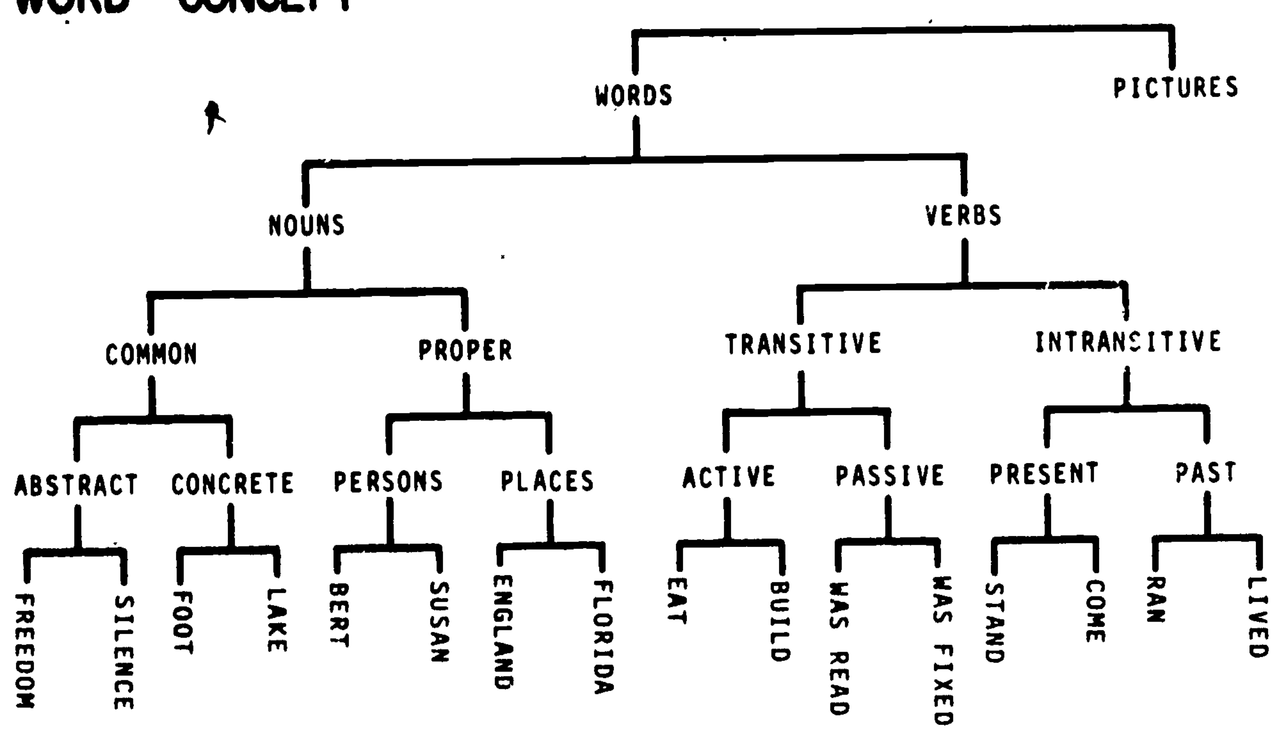
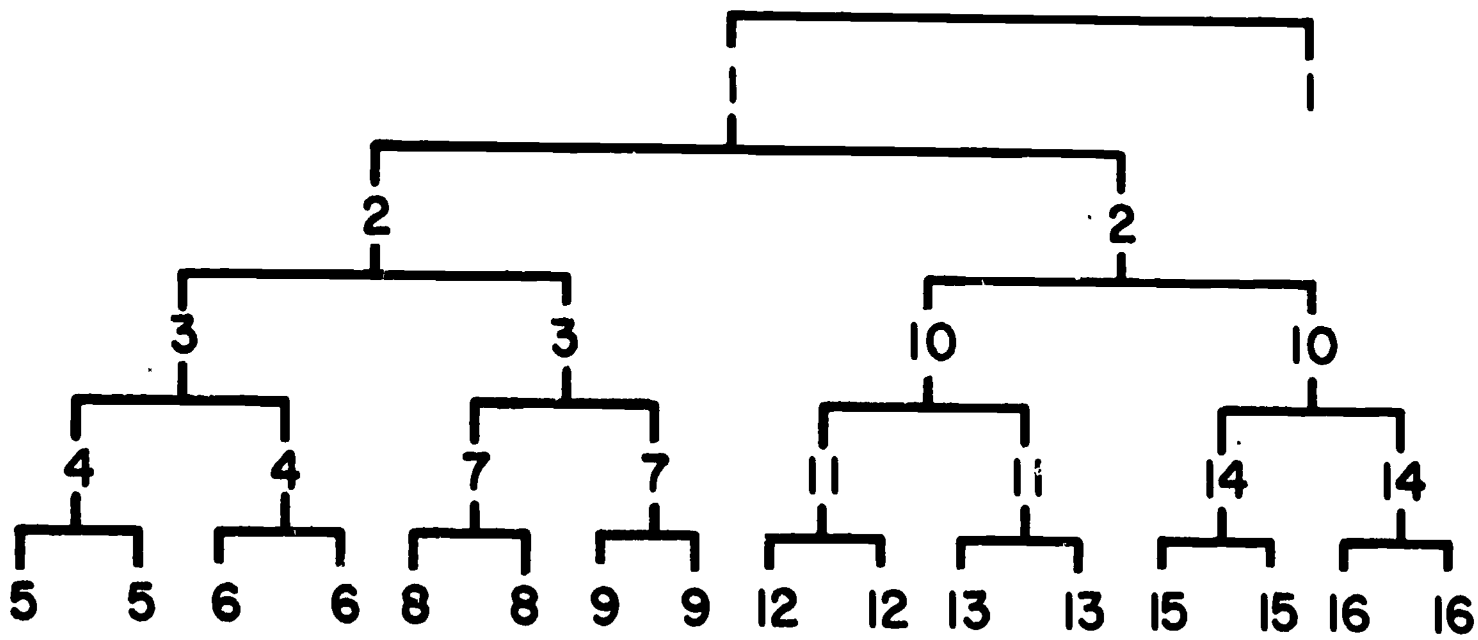



Figure 16. Hierarchies Which Were Stimulus Displays for Study 5B, and Which Included "Tangible" Concept and "Word" Concept

SUPERORDINATE TO SUBORDINATE ORDER




SUBORDINATE TO SUPERORDINATE ORDER

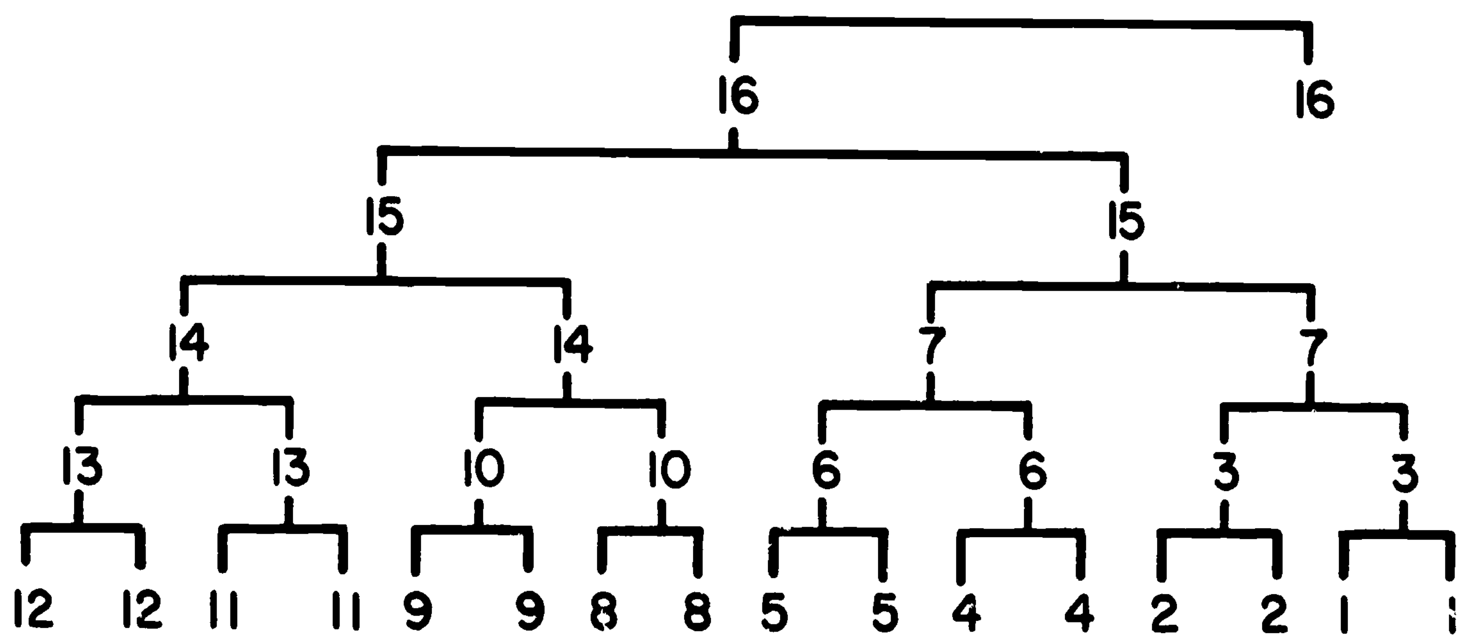



Figure 17. Temporal Orders of Presentation of Pairs of Elements in Hierarchies, Which Orders Constituted the Two Treatments -- Superordinate Order and Subordinate Order

pattern chosen by some subjects in Study 3 (Figure 9). One branch of the hierarchy is followed down through elements at all levels, then another branch is followed down. Another pattern is the Super-across pattern, which was also exhibited by Study 3 subjects. With it, all elements at one level are dealt with before the next lower level is begun.

It was anticipated that the variance ascribable to the particular concept, "Tangible" or "Word," would be larger than that ascribable to the order in which treatments were administered. Consequently, concepts were counterbalanced across treatments as shown in Table 33. Treatments were administered successively, superordinate first, to each of the two extant class groupings of 16. Subjects were the same as in Method A.

TABLE 33. COUNTERBALANCING OF CONCEPTS ACROSS TREATMENTS FOR THE TWO EXPERIMENTAL GROUPS

| Group | Treatments | |
|---|---|---|
| | Superordinate order | Subordinate order |
| #1 | "Tangible" concept | "Word" concept |
| #2 | "Word" concept | "Tangible" concept |

When the display was removed, subjects were to write all words they could recall on a response sheet which showed a comparable hierarchical structure having empty spaces for 32 words.

Scores consisted of the number of words recalled out of the 32 presented, regardless of where the words were written in the spaces on the response sheet.

## Results B

Mean scores by treatments and by concepts, Table 34, indicate that concepts were the apparent major source of variance. No overall differences in numbers of words recalled appears to be ascribable to treatments. In the further analysis of these findings, which follows, all differences tested are within concepts.

There appeared to be differential recall of the 16 superordinate elements in each hierarchy as compared to the 16 subordinate elements,

TABLE 34. COMPARISON OF MEAN NUMBERS OF ELEMENTS RECALLED IN RELATION TO TREATMENTS (SUPERORDINATE AND SUBORDINATE ORDERS OF PRESENTATION) AND CONCEPTS (TANGIBLE AND WORD)

| Concept | Treatments (orders of presentation) | |
|---|---|---|
| | Superordinate | Subordinate |
| "Tangible" | 17.7 | 17.6 |
| "Word" | 13.4 | 13.9 |

Figure 18. As shown in Table 35, the mean number of items recalled is consistently higher for the 16 superordinate elements than for the 16 subordinate elements. The differences between the four pairs of means (for the 16 superordinate elements vs. the 16 subordinate elements) were t-tested and three of the four were found to be significant ($p < .025$). This was the case regardless of which 16 were presented first (superordinate order or subordinate order) and regardless of concept, "Tangible" or "Word."

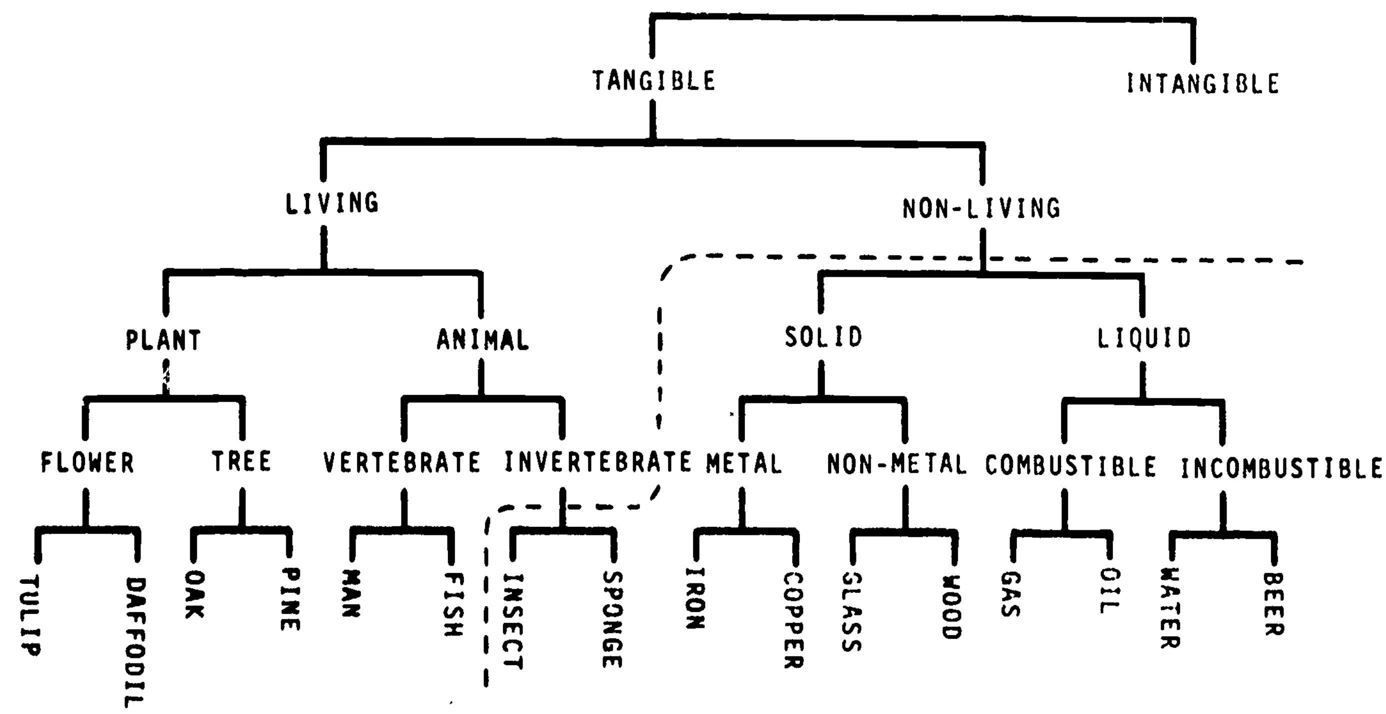
TABLE 35. ANALYSIS OF MEAN NUMBER OF ELEMENTS RECALLED OF THE SUPERORDINATE 16 AND SUBORDINATE 16 FOR EACH CONCEPT IN EACH TREATMENT (ORDER OF PRESENTATION)

| Order of presentation | Concept | Elements in hierarchy | | t-value |
|---|---|---|---|---|
| | | Superordinate 16 | Subordinate 16 | |
| Superordinate to Subordinate | "Tangible" | 11.6 | 6.1 | 5.66* |
| | "Word" | 8.3 | 5.1 | 4.57* |
| Subordinate to Superordinate | "Tangible" | 9.2 | 8.4 | 0.70 |
| | "Word" | 8.4 | 5.5 | 2.54* |

*$p < .025$

There was also the possibility that there might be differential recall of either the 16 superordinate or 16 subordinate elements as a function of treatment, although it had been noted, Table 34, that no

## "TANGIBLE" CONCEPT




## "WORD" CONCEPT

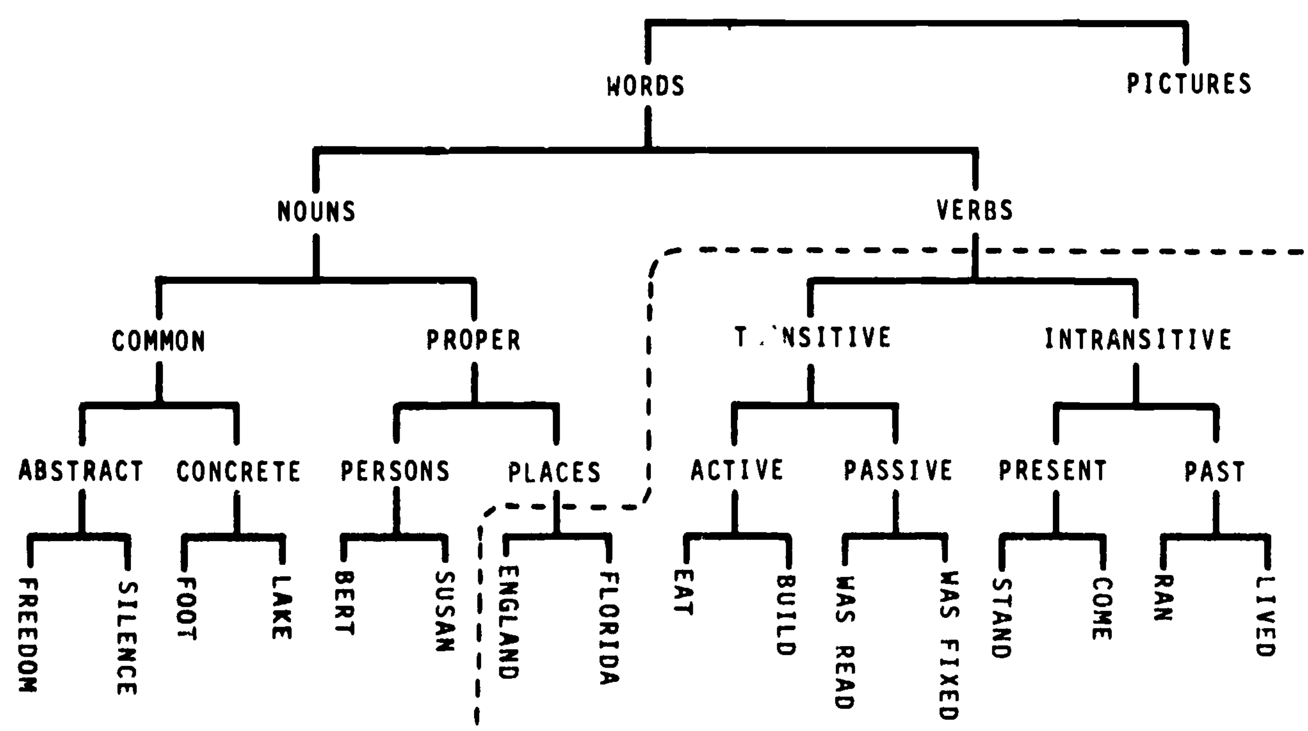



Figure 18. Dotted Line Separates Elements Designated Superordinate 16 (Upper Left) From Elements Designated Subordinate 16 (Lower Right) in Each Hierarchy. Superordinate 16 Were Presented First in Superordinate Order of Presentation While Subordinate 16 Were Presented First in Subordinate Order of Presentation

difference was attributable to treatment when all 32 elements were considered. Table 36 shows the means under consideration. The means for the "Word" concept show no differences across treatment levels, while the means for the "Tangible" concept do show differences across treatment levels as well as an interaction. An Analysis of Variance of the "Tangible" concept data was computed by using a design for two-factored experiments with repeated measures on one factor, Winer (43:302). The summary is given in Table 37 and shows a significant main effect for Position of elements (B), there being a larger number of superordinate elements in the hierarchy that were recalled than of the subordinate elements. There was also a significant AB interaction.

TABLE 36. COMPARISON OF MEAN NUMBER OF ELEMENTS RECALLED OF THE SUPERORDINATE 16 AND SUBORDINATE 16 FOR EACH TREATMENT (ORDER OF PRESENTATION)

| Treatments, orders of presentation (A) | Elements in hierarchy (B) | | | |
|---|---|---|---|---|
| | "Word" concept | | "Tangible" concept | |
| | Superordinate 16 elements ($b_1$) | Subordinate 16 elements ($b_2$) | Superordinate 16 elements ($b_1$) | Subordinate 16 elements ($b_2$) |
| Superordinate $a_1$ | 8.3 | 5.0 | 11.6 | 6.1 |
| Subordinate $a_2$ | 8.3 | 5.5 | 9.2 | 8.4 |

TABLE 37. ANALYSIS OF VARIANCE FOR TREATMENT SCORES (ORDER OF PRESENTATION) ("TANGIBLE" CONCEPT) IN RELATION TO POSITION OF ELEMENTS IN HIERARCHY (SUPERORDINATE 16 AND SUBORDINATE 16)

| Source of variation | SS | df | MS | F |
|---|---|---|---|---|
| <u>Between</u> <u>subjects</u> | 401.61 | | | |
| A (order of presentation) | 0.01 | 1 | .01 | |
| Subjects within groups | 401.60 | 30 | 13.38 | |
| <u>Within</u> <u>subjects</u> | 487.50 | | | |
| B (position of elements) | 153.14 | 1 | 153.14 | 18.65** |
| AB | 87.89 | 1 | 87.89 | 10.70** |
| B x Subjects within groups | 246.47 | 30 | 8.21 | |

**p $<$ .01 at 1,30 df

Tests of the simple main effects, Winer (43:310), are given in Table 38. For each position of elements (superordinate 16 and subordinate 16) there was a significant difference in the number of elements recalled under one order of presentation than under the other. However, the direction of the difference varied (Table 36, "tangible" concept) there being more of the superordinate 16 elements recalled when they were presented first ($a_1$) and more of the subordinate 16 elements recalled when they were presented first ($a_2$). Also, as noted in previous t-tests (Table 35), the differences between the number of superordinate 16 and subordinate 16 elements recalled is significant under the superordinate order of presentation but not under the subordinate order.

TABLE 38. ANALYSIS OF SIMPLE MAIN EFFECTS ("TANGIBLE" CONCEPT) FOR ORDER OF PRESENTATION AND POSITION OF ELEMENTS IN HIERARCHY

| Source of variation | SS | df | MS | F |
|---|---|---|---|---|
| Between subjects | | | | |
| A (order of presentation) at $b_1$ (superordinate 16) | 45.12 | 1 | 45.12 | 125.40** |
| A (order of presentation) at $b_2$ (subordinate 16) | 42.78 | 1 | 42.78 | 118.89** |
| Within cells | 21.59 | 60 | 0.36 | |
| Within subjects | | | | |
| B (position of elements) at $a_1$ (superordinate order) | 236.53 | 1 | 236.53 | 28.81** |
| B (position of elements) at $a_2$ (subordinate order) | 4.50 | 1 | 4.50 | 0.55 |
| B x subjects within groups | 246.47 | 30 | 8.21 | |

**$p < .001$

Also examined were the task recall scores in relation to one of the standard test scores, Closure Flexibility, which test correlated most highly with task scores in Study #4. The means for high and low scorers (Closure Flexibility) in two treatment groups (superordinate and subordinate orders) encountering the "Tangible" concept are shown in Table 39. An Analysis of Variance for these data yielded the mean squares shown in Table 40. The main effect for Closure Flexibility was significant ($p < .01$). However, there was a significant AB interaction.

The summary of the analysis of the simple main effects is given in Table 41. Under one treatment, subordinate order, the high Closure

TABLE 39. COMPARISON OF MEAN NUMBER OF ELEMENTS RECALLED UNDER EACH ORDER OF PRESENTATION BY HIGH AND LOW SCORING (CLOSURE FLEXIBILITY) SUBJECTS

| Closure Flexibility scores (A) | Order of presentation (B) | |
|---|---|---|
| | Superordinate ($b_1$) | Subordinate ($b_2$) |
| High ($a_1$) | 18.62 | 22.37 |
| Low ($a_2$) | 16.75 | 12.87 |

TABLE 40. ANALYSIS OF VARIANCE FOR TREATMENT SCORES (ORDER OF PRESENTATION) ("TANGIBLE" CONCEPT) BY SUBJECTS AT TWO LEVELS OF PERFORMANCE ON A STANDARD MEASURE (CLOSURE FLEXIBILITY)

| Source of variation | SS | df | MS | F |
|---|---|---|---|---|
| A (Closure Flexibility) | 258.78 | 1 | 258.78 | 16.92** |
| B (Order of Presentation) | 0.03 | 1 | 0.03 | |
| AB | 116.28 | 1 | 116.28 | 7.60* |
| Within cells | 428.13 | 28 | 15.29 | |
| Total | 803.22 | 31 | | |

*$p < .05$ at 1,28 df　　**$p < .01$

TABLE 41. ANALYSIS OF SIMPLE MAIN EFFECTS FOR STANDARD MEASURE (CLOSURE FLEXIBILITY) AND TREATMENT SCORES (ORDER OF PRESENTATION) ("TANGIBLE" CONCEPT)

| Source of variation | SS | df | MS | F |
|---|---|---|---|---|
| A (Closure Flexibility) for $b_1$ (superordinate order) | 14.06 | 1 | 14.06 | |
| A (Closure Flexibility) for $b_2$ (subordinate order) | 361.00 | 1 | 361.00 | 23.61** |
| B (Order of Presentation) for $a_1$ (High Closure Flexibility) | 56.25 | 1 | 56.25 | 3.68* |
| B (Order of Presentation) for $a_2$ (Low Closure Flexibility) | 60.06 | 1 | 60.06 | 3.93* |
| Within cells | 428.13 | 28 | 15.29 | |

*$p < .10$ at 1,28 df　　**$p < .01$

Flexibility subjects achieved task scores that differed from the low Closure Flexibility subjects by an amount significantly exceeding chance ($p < .01$). This was not the case under the other treatment, superordinate order. However, differences between means were in the same direction in both cases, i.e., high task scores were associated with high standard measure scores. (Table 39)

For high Closure Flexibility subjects the subordinate order of encounter was superior, while for low Closure Flexibility subjects the superordinate order of encounter was superior, Table 39. However, the probability is 10 in 100 that these differences occurred by chance, Table 41.

To further explore the possible relationships between standard cognitive measures and task scores, Spearman Rank Correlations were computed between Closure Flexibility, Wonderlic, and Study 5B scores. The latter were the total scores, combining the scores for both conditions and both concepts. (See data in Appendix E.) As can be seen in Table 42, the correlation between task scores and Closure Flexibility scores was 0.54 and that between task scores and Wonderlic scores was 0.48. A t-test of these values indicates that both are significant correlations ($p < .01$).

TABLE 42. CORRELATIONS BETWEEN STANDARD SCORES (CLOSURE FLEXIBILITY AND WONDERLIC) AND TASK SCORES (STUDY 5B)

| | Standard test scores | | Task scores |
|---|---|---|---|
| | Closure Flexibility | Wonderlic | Total score Study 5B |
| Closure Flexibility | | .51 | .54 |
| Wonderlic | .51 | | .48 |
| Total score Study 5B | .54 | .48 | |

## Method C

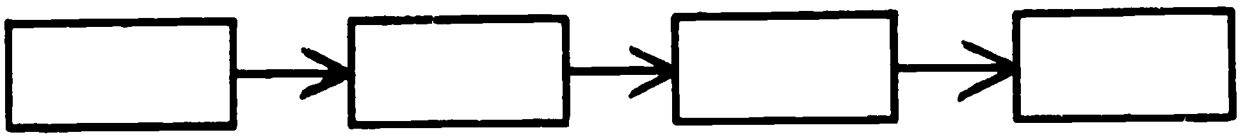
Subjects were given a response sheet on which were three linear iconic structures and a list of 18 proper names, Figure 19. They were instructed to choose names from the list and enter them in the boxes. If the different structures suggested different relationships between boxes, the subjects were to choose and arrange names in the structures

NAMES

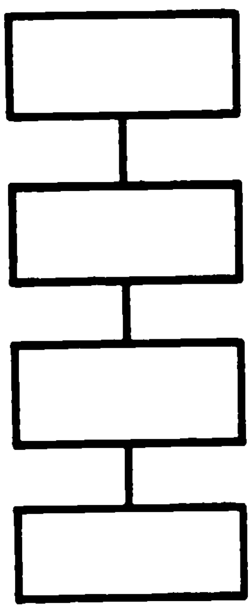
| | | |
|---|---|---|
| ARISTOTLE | JOHN F. KENNEDY | ALBERT SCHWEITZER |
| CALVIN COOLIDGE | ROBERT E. LEE | SHAKESPEARE |
| WINSTON CHURCHILL | ABRAHAM LINCOLN | RICHARD SPECK |
| IAN FLEMING | HENRY LONGFELLOW | JOSEPH STALIN |
| ADOLF HITLER | DOUGLAS MACARTHUR | HARRY TRUMAN |
| HOMER | MARCEL PROUST | GEORGE WASHINGTON |

LINEAR STRUCTURES

1.



2.



3.

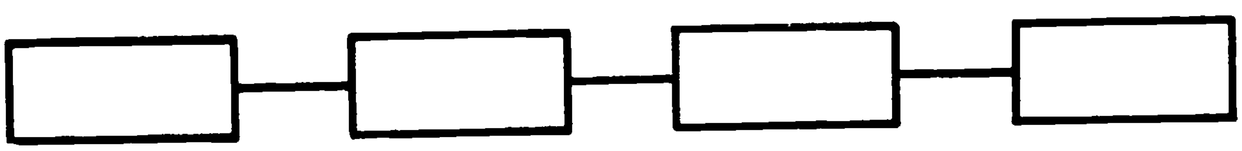


Figure 19. Names and Linear Structures on Response Sheets for Study 5C. Subjects Were to Choose Names and Insert Them as Appropriate for Each Structure

in a way consistent with the perceived relationships. They were also to state briefly their rationale for arranging the names as they did. There was no time limit for the task.

Subjects were the same as those participating in Methods A and B.

## Results C

Responses were placed into either Equivalence or Order categories based on the subject's stated rationale. "Equivalence" responses were those for which the subject's rationale was an unordered grouping. Typically, such a rationale would be, "All presidents of the U.S.," or, "All authors." "Order" responses were those that did indicate some continuum or progression. Typically, the ordering was chronological, such as "Presidents in the order in which they served," or "Poets from ancient to modern."

The frequency of Equivalence and Order responses to the three linear structures is shown in Table 43. The Cochran Q Test for _k_ related samples (33) was applied to the frequencies of Order responses. A Q value of 15.6 at df = 2 indicates that the frequency of Order responses across the three iconic structures differed by an amount ($p < .001$) significantly exceeding chance.

TABLE 43. FREQUENCIES OF EQUIVALENCE AND ORDER RESPONSES TO THREE LINEAR STRUCTURES AND ANALYSIS OF DIFFERENCES IN FREQUENCIES OF ORDER RESPONSES

| Response type | Iconic structure types | | | |
|---|---|---|---|---|
| | #1 Linear with arrows | #2 Linear vertical | #3 Linear without arrows | Cochran Q Test |
| Equivalence | 16 | 20 | 30 | |
| Order | 17 | 13 | 3 | Q = 15.6* |

*$p < .001$ at 2 df

The greatest difference was between #1 and #3 in Figure 19, which were the two horizontal linear structures, with and without arrows. About 50% were Order responses for the structure with arrows, while only about 10% were Order responses for the structure without arrows, as shown in Table 43.

## Findings and Discussion

The purposes of Study #5 centered around four questions.

1. Will the effect on recall be positive where the recall context is structurally the same as the learning context, and will the effect be negative where the learning and recall contexts differ structurally?

The observed differences between the means for the three conditions were not found to be statistically significant. Recall was, however, found to be greatest where the recall context was the same as the learning context, and recall was progressively less for the two progressively different recall contexts.

2. Will recall of elements in a hierarchy be influenced by the order of presentation--superordinate to subordinate or subordinate to superordinate?

In general, no. There was not a significant main effect attributable to the order of presentation. However, for one of the concepts ("Tangible") there was a significant interaction between the order of presentation and the position of the elements in the hierarchy. More superordinate elements were recalled when they were presented first, and more subordinate elements were recalled when they were presented first. This had the appearance of a primacy effect.

The principal sources of variance were the particular concepts employed in the hierarchies ("Tangible" and "Word") and the position of elements in the hierarchy (superordinate and subordinate). An observation about each may be appropriate.

Although the means for the "Tangible" concept were overall higher (17.7) than for the "Word" concept (13.6) there were some internal similarities and differences. As shown in Table 44, the upper 16 elements (top 4 levels) were recalled about equally well overall for <u>both</u> concepts. Also, for both concepts fewer of the lower 16 elements (bottom level) were recalled than of the upper 16, but the drop was about twice as great for the "Word" concept. Thus, the primary difference between responses to the two concepts appears to be localized in the lower 16 elements of the "Word" concept. Examination of the lower 16 elements for both concepts, Figure 16, suggests that those in the "Word" concept are more subordinate than those in the "Tangible" concept. For example, the four proper nouns in the "Word" concept refer to identity categories (16), i.e., they each refer to one thing, while all other words in both concepts refer to equivalence categories (16), i.e. to groups of different things. Subjectively, the lower 16 words in the "Word" concept appear to be more arbitrary choices from a larger universe than were the comparable elements of the "Tangible" concept. Knowing the words immediately above them would not cue their recall.

TABLE 44. COMPARISON OF MEAN NUMBERS OF ELEMENTS RECALLED IN RELATION TO CONCEPT AND TO LEVEL OF HIERARCHY

| Concept | Level in hierarchy | |
|---|---|---|
| | Upper 16 (top 4 rows) | Lower 16 (bottom row) |
| "Tangible" | 10.93 | 6.72 |
| "Word" | 10.12 | 3.50 |

The fact that there was an overall tendency for superordinate words to be better recalled than subordinate words cannot satisfactorily be accounted for, though there are several plausible possibilities--the superordinate words may be more familiar or have a greater number of associations. Several such alternatives are considered with reference to related studies in the Discussion section of Chapter VII.

As mentioned in Method B, the term "Superordinate order" can be variously operationalized--Super-sider, Super-across, etc. As shown in Table 45, the Super-sider order employed in Study 5 involved more downward movements (superordinate to subordinate) and fewer across, but it also involved more upward movements. The comparative efficiency of the two Superordinate orders might be profitably studied experimentally.

TABLE 45. COMPARISON OF ORDERS OF PRESENTATION OF ELEMENTS IN A HIERARCHY WITH REFERENCE TO DIRECTION OF SUCCESSIVE MOVES (FIGURES 9 AND 17)

| Orders of presentation | Direction of moves | | |
|---|---|---|---|
| | Down | Across | Up |
| Super-sider | 8 | 4 | 3 |
| Super-across | 4 | 11 | 0 |

3. Will subjects assigning meaningful elements to linear structures differentiate between certain types of linear structures (horizontal or vertical, with or without arrows) in a way comparable to that found in Study 1 with reference to hypothetical elements and relationships?

Yes, for horizontal structures #1 and #3, Figure 19, for which direct comparisons can be made. The empty linear structure with arrows

in Study 1 was rated 4.46 (shows relationship) for before-after relationships, while the same structure without arrows in Study 1 was rated 2.13 (does not show relationship), Table 5. Comparably, the horizontal linear structure with arrows in Study 5C was assigned a significantly greater number of Order responses (typically before-after relationships) than the linear structure without arrows. Data for the vertical linear structure with reference to before-after relationships were not available in Study 1.

4. Will responses to the learner structure measures be correlated with responses to the above tasks?

Yes, for 5B data. The scores for task 5B, regardless of treatment or concept, were significantly and positively correlated with both Closure Flexibility scores and Wonderlic scores.

## CHAPTER VII

## DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

### Discussion

That learners tend both to seek order in their world and impose order on their world was an assumption of this study rather than a hypothesis to be tested. The questions being investigated were those that follow from the above assumption, such as what kinds of orderings in the environment (message structures) are preferred by the learner, in what ways are these orderings used or modified within the constraints of various tasks, and to what degree might these behaviors be correlated with individual differences (learner structures)? In the words of this study the pervasive question was: Given a certain organized body of knowledge (knowledge structure), and given learners with certain cognitive styles and predispositions (learner structure), what kinds of messages and message materials (message structure) would constitute the optimum design for learning?

What follows is a discussion of several aspects of this question with reference both to the findings of this study and to those of related studies. The more generally related literature was examined in Chapter I, the section on Background of the Problem. Occasional reference will be made to certain of those studies in what follows, but most reference will be to additional and more specifically related studies.

There is evidence from the literature that people respond differentially to linear (words, music) and iconic (art objects) orderings of their environment (13). Further, such response differences appear to involve two types of synthetic or integrative activity, successivity and simultaneity, which may have their physiological counterparts (19). There is related evidence that people in an unordered situation impose orders of different types on the situation, orders that may suggest commonality with the above categories, simultaneity and successivity. For example, Kuethe and DeSoto (17) attempted to assess grouping vs. ordering tendencies. Subjects were shown geometric figures that could be either ordered by size (successivity?) or grouped by color (simultaneity?). Findings were that, when free to do either, subjects tended to group. However, the investigators noted that both schemata were freely employed and could be seen as mutually facilitory rather than intrinsically antagonistic. In Study 5C subjects were free to use any schema for the selecting and organizing of proper names which was judged to be consistent with given iconic structures, Figure 19 and Table 43. The use of grouping (Equivalence) schemata were significantly associated with the linear structure having no arrows (simultaneity?), while ordering schemata were significantly associated with the linear structure with arrows (successivity?). Operationally, ordering was a magnitude relationship for Kuethe and DeSoto subjects and a temporal relationship for Study 5C subjects. In both studies changes in task constraints

(constraints of very different kinds) were associated with differing tendencies to group or order.

As noted in the section, Background of the Problem, Jensen (14: 147) has expressed doubt about the merit of attempting to relate standard psychometric test scores to task scores in studies of concept learning. He doubts that, "there is much to be gained from determining correlations between single learning measures and extrinsic factors. The results are too uninterpretable, since some change in the conditions of learning can completely alter the pattern of correlations between learning measures and extrinsic measures" (standard tests). Of interest in this regard are the interactions between intrinsic factors (constraints) in Study 5C (above) and between intrinsic and extrinsic factors in 3B and 4B (to follow).

In Study 3B, subjects performed the same task under two conditions, one permissive (free) and the other demanding (constrained). The constraints consisted of appeals to employ their best strategies because the optimum strategies had been determined by computer, and further that MIT and Harvard students had been able to achieve an accuracy of 85% on the task (both being fabrication). Response changes were significant from the free to the constrained condition, Table 15. Further, two-thirds of those who changed strategies (in response to intrinsic factors) were those who scored high (upper half of group) on an extrinsic measure, the Siegel and Siegel Educational Set Scale (32), Table 16.

In Study 4B, subjects performed a card sorting task. Subjects were to group and sequence the cards in a way that would optimize learning, but were not informed that the words on the cards were hierarchically related. Analysis of the subjects' groupings was done both in relation to the experimenters' preconceived categories and the subjects' own categories. The consequent scores were in interaction with the experimental conditions, Table 29, the greater mean for each scoring method being associated with a different condition. The two sets of task scores correlated quite differently with an external factor, Closure Speed scores, $r = .07$ as compared to $-.35$ (Table 31). Mandler and Pearlstone (20) carried a card sorting task beyond the concept identification phase to concept learning. The elements were words, as in Study 4B, as well as figures. Free subjects were permitted to form and learn their own concepts, while constrained subjects were required to learn predetermined concepts (actually those formed by yoked subjects in the free condition). There were significant main effects for errors and for time, both favoring the free condition. There was noted a tendency for each subject in the free group to form a consistent number of concepts across the four sets of elements, both verbal and figural.

In addition to the above interactions between intrinsic (task related) factors and extrinsic factors (standard psychometric scores) there were several examples of significant positive correlations (Studies 4A and 5B) between task scores and scores on standard tests (Closure Flexibility, Closure Speed, Wonderlic Personnel Test). On balance, the

data are inadequate to establish whether most variance is ascribable to intrinsic or to extrinsic factors. It is apparent that intrinsic factors such as changes in task constraints can markedly alter behavior. As constraints change, they may provide the occasion for the effects of external factors to be observed.

If, in the above references to Studies 3B, 4B, and 5C, as well as 4A and 5B, task conditions and constraints can be construed as message structure variables, and if the standard measures are accepted as learner structure variables, a frequent tendency can be observed for there to be associations and interactions between message structure and learner structure.

Regarding the knowledge structure factor, several studies have examined ways of representing and teaching concepts having hierarchical or subsumptive relationships. For example in a study of concept identification by Stone (35), the experimental group was given a representation that served as an analogy to the subsumptive relationship that was to be learned. The representation was as follows:

Animal

  Wild

    Lion

    Tiger

  Tame

    Dog

    Cat

This concept could as well have been represented by an iconic hierarchical structure such as those in the present study. However, the above representation is a common way of depicting subsumption or hierarchality. Subjects were given 24 presentations in which a geometric figure was accompanied by the statement, "This is ______." or "This is not ______." The names were nonsense syllables, seven of them, which bore a subsumptive relationship to each other like that above. Responses of the precued subjects were superior by a significant amount, $p < .01$. Study 4A was comparable in that a representation of the relationship to be discovered was given to the experimental group (Structure Salient group). In this case the representation was an iconic structure suggesting the relationships among four members of a family, Figure 12. Means for the experimental group were higher, though not by an amount significantly exceeding chance. One difficulty was that the iconic representation was presented as an optional aid, and many of the subjects did not appear to make appreciable use of it. Study 5B, which dealt with hierarchical relationships, is discussed at the end of this section in relation to a series of studies by Bower (3).

Regarding the temporal dimension of message structure, Bruner has stated the following theorems:

1. "Sequences of learning can be devised to optimize the achievement of different objectives. One cannot, therefore, speak of the optimal sequence for presenting a body of knowledge."

2. "If the underlying economical structure of a set of facts is to be grasped conceptually and readily transferred to new instances, then it is better to learn the basic conceptualization by induction from particular instances. In this manner the learner grasps both the generalization and a range of its applicability at the same time." (5:205-206)

This would indicate that an order characterized as from instances to concept is preferred for teaching underlying structure and to facilitate transfer.

With regard to temporal order Hickey proposed the following hypothesis:

"Concept acquisition and transfer are optimized when, in the first stage, relationships among stimulus elements are learned inductively from examples, and in the second stage, relationships between stimulus and response elements are stated first, and then illustrated with examples." (11:XI)

The above statements would seem to divide the sequence in two, the first being consistent with Bruner in prescribing an exemplar-to-concept order, and the second prescribing the inverse order. Hickey also hypothesized that the ordering of conceptual elements, such as those in a logic tree, Figure 1, page 10, should proceed from the elementary to the complex.

Another temporal order scheme comes from Gagné (9). He posited a hierarchy of eight types of learning from signal learning to problem solving. A learning structure for a topic, Figure 1, page 10, typically includes several of the types of learning. An optimum learning sequence is said to build from the lower or prerequisite types of learning to the related higher-order concepts and principles.

Study 5B examined temporal orders of presentation of words in a hierarchy. Because this was a verbal memory task, comparison with the concept formation studies of the above men is questionable. Nonetheless the orders of presentation discussed by Bruner and Hickey have their counterparts in the superordinate and subordinate orders employed by Study 5B. A subordinate-to-superordinate order would be comparable to that favored by Bruner and Hickey. Study 5B found no main effect for temporal order. It was found that regardless of temporal order of presentation the more superordinate words tended to be recalled more consistently than the more subordinate words, Table 35, Figure 18. It

would be expected that the more frequently occurring the words the more readily they would be remembered. A check of the relative frequency of occurrence of the words in the language, Thorndike and Lorge (37), revealed that the 16 superordinate words occurred essentially as frequently for one concept and slightly less frequently on the average for the other concept than the 16 subordinate words. Hence, relative frequency does not account for the larger number of superordinate words remembered. To the extent that the superordinate words could be considered less concrete, they would have been expected to be less well memorized than the subordinate, more concrete words, Paivio (23). This is the inverse of what occurred. Some unidentified aspect of the iconic hierarchical structure itself might be a determining factor. For example, the lower density of elements in the upper part of the structure might make that part appear more comprehensible. Subjects in earlier studies in the present series exhibited consistent preferences for encountering superordinate elements first. It was also apparent from earlier studies that in order to identify an element at the third (from the top) level of a hierarchy subjects moved from levels 1 or 2 down to 3. To the extent this implied that superordinate elements were judged to be more important or to give more useful information, it would follow that in a learning situation such as 5B subjects would give a higher priority to the learning of superordinate elements. Or again, it is plausible that college students have a larger number of associations for superordinate words and thus can retain them better.

The most recent and closely related work was a series of studies reported by Bower (3). He studied hierarchies in the context of cognitive elaboration and organization in memory. He judged the hierarchical mode of presentation to be potentially powerful because of the organization of input and the implicit cueing of recall it appeared to provide. He constructed four conceptually distinct hierarchies of about 28 words each like the example in Figure 20, making a total of 112 words. In one condition the four groups of words were presented in proper hierarchical organization, while in the other the words were randomly distributed across the four hierarchical structures. Subjects were given four trials, the first on levels 1 and 2 of the hierarchies only, the second on levels 1, 2, and 3, and the third and fourth on all four levels, Figure 20. The thought was that presenting the superordinate level words first might facilitate recall of the subordinate level words. As shown in Figure 21, Bower's organized group far exceeded in recall the random group. In only four trials the organized group learned an average of 108 words (96%) while the random group learned 46 (41%).

Other combinations were tried by Bower. For example, two other groups encountered just the subordinate level words (level 4) for two hierarchies. They were given two trials on the 48 subordinate words. Then one group learned the matching or relevant superordinate words, levels 1 to 3, while the other group learned as many irrelevant words. Both groups were asked to recall all of the words. As shown in Table 46, for the third trial on the level 4 words, the performance of the group which had learned the relevant superordinate words improved 25%, while

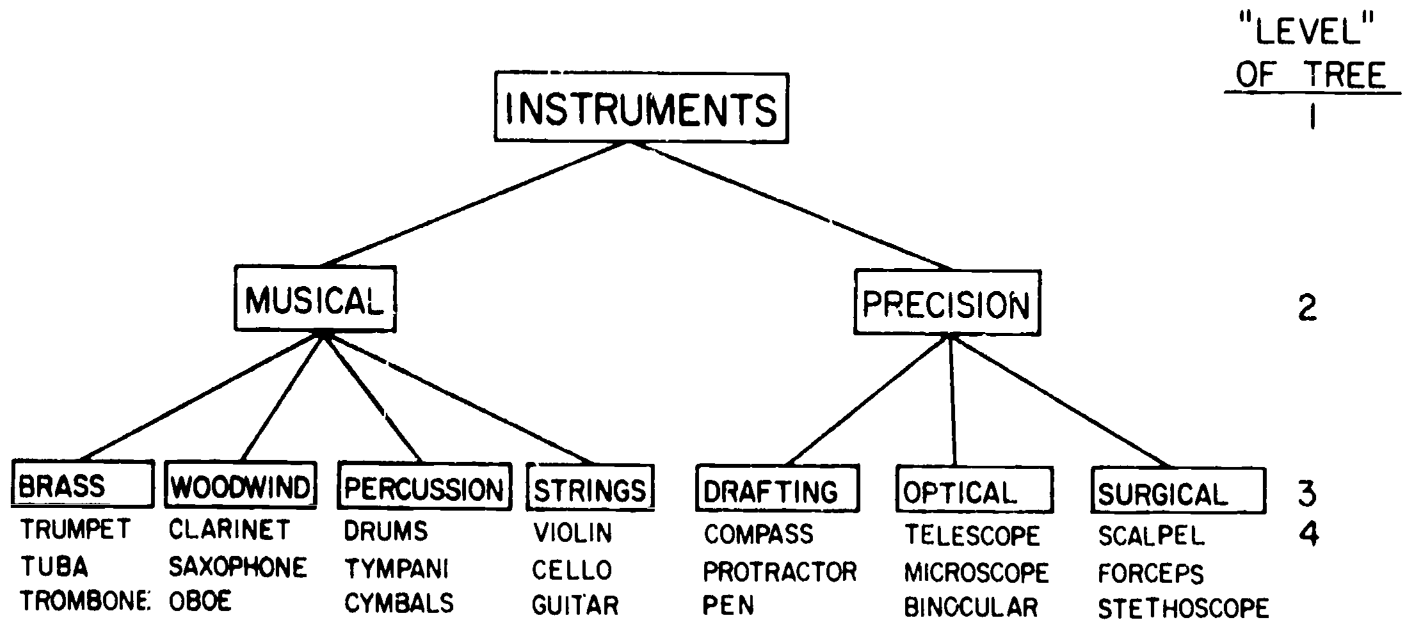



Figure 20. Example of One of Four Hierarchies From Bower Study

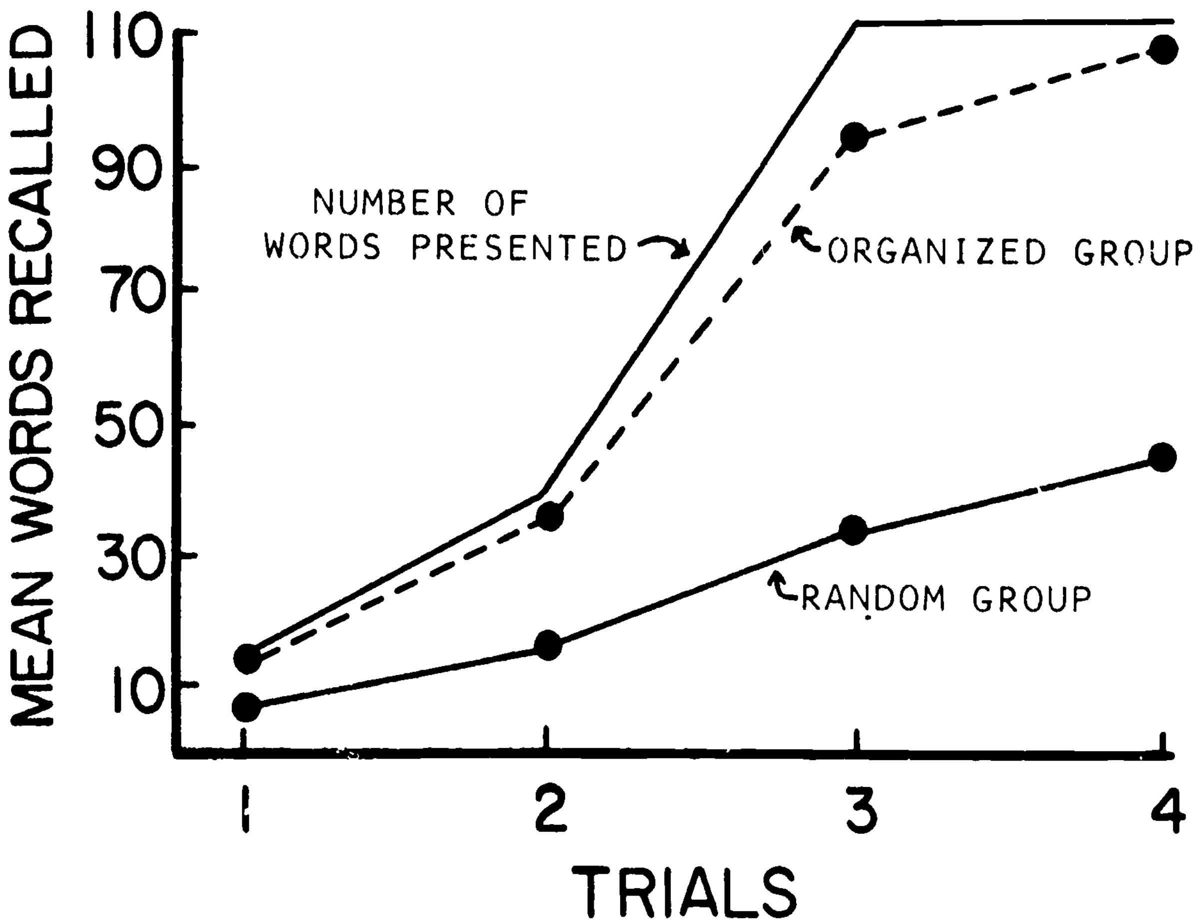



Figure 21. Mean Words Recalled Per Trial From Progressively Revealed Hierarchies in Which Words Were Either Organized or Random (Bower Study)

that of the group learning the irrelevant superordinate words dropped slightly. Finally, the latter group was provided the relevant superordinate words as a context in which to make a f urth trial. This time their recall was 41.1, approximating that of the relevant group, 44.4.

Though Bower's studies included different orders of encounter, superordinate words first or subordinate words first, the two orders were not directly compared as they had been in Study 5B. It is apparent the superordinate words served a cueing or mediating function for the subjects, thus facilitating recall of the subordinate words. It is not clear, however, that superordinate words were themselves learned better than subordinate words, a condition found in Study 5B. An eyeball estimate based on Figure 21 would suggest that it was the subordinate words that were learned more rapidly than the superordinate, at least after the latter had been learned. The superordinate third of the words was learned in the first two trials, while the subordinate two-thirds were learned in the last two trials. This appears to conflict with the findings of the present study. Thus the temporal order factor and the phenomenon of superior learning of superordinate words remain to be further examined in replications and extensions of such studies.

Bower points out the tremendously powerful effect on memory of such organizational or structural aids in comparison to the traditional learning paradigms. For example, he contrasted the standard free recall experiment using 8 to 24 words presented for 10 to 20 trials with the 108 words learned in 4 trials using the organized presentation. Bower's studies, not yet reported in journal form, provide solid support for many of the preliminary findings of the present study with regard to iconic knowledge structures of the hierarchical type.

TABLE 46. MEAN RECALL OF 48 SUBORDINATE (LEVEL 4) WORDS FOR EACH TRIAL BY SUBJECTS LEARNING RELEVANT OR IRRELEVANT SUPERORDINATE WORDS (LEVELS 1-3) BETWEEN TRIALS TWO AND THREE, FOR BOWER STUDY (3)

| Trials | Superordinate words | |
|---|---|---|
| | Relevant | Irrelevant |
| 1 | 27.8 | 24.2 |
| 2 | 35.6 | 34.7 |
| 3 | 44.4 | 34.2 |

## Conclusions

The word "conclusion" is essentially incompatible with the word "exploratory" which characterized this study from the outset. Though several conclusions will be offered, these are tentative except where the results of this series of studies are consonant with the results of other studies.

Conclusion #1 -- The general conclusion that learning can predictably be facilitated or retarded according to the structure of the message (stimulus) has been repeatedly demonstrated across several types of learning (paired associate, serial, concept) and with several types of message vehicles (verbal, figural, pictorial). However, the specific findings indicate that particular types of learning may be differentially associated with particular types of message structure. Further, the strength of the association is multiply determined by interacting factors such as knowledge structure, learner structure, and task constraints.

Specific to this study were several more specific and tentative conclusions:

Conclusion #2 -- Graduate students in education perceive certain iconic knowledge structures as differentially depicting the following types of substantive relationships: magnitude relationships, temporal relationships, causal relationships, and hierarchical relationships.

Conclusion #3 -- The above perceptions of relationships are shown to be selectively sensitive to changes in orientation of the structures and to changes in attributes such as the addition or deletion of arrows.

Conclusion #4 -- The characteristics of the perceived relationships between substantive elements vary systematically with the position of the elements within the structures.

Conclusion #5 -- Judgments by graduate education students of the optimum temporal order in which to encounter the substantive elements in an iconic knowledge structure exhibit several patterns. These patterns or learner-strategies are to a degree characteristic of the different iconic structures. However:

A. Some individuals tend to be consistent in their preferences for similar temporal order patterns across different knowledge structures.

B. When motivational constraints are applied to this judgmental task, individuals who score high on the Siegel Test of Educational Set tend to modify their judgments more than individuals scoring low, and the direction of this change is from logically "poor" strategies to logically "good" strategies.

Conclusion #6 -- Scores on various standard test instruments frequently are not found to be associated with judgments or preferences on various experimental tasks. However, several exceptions were observed:

A. Students scoring high on the Siegel Test of Educational Set exhibited a strong preference for certain patterns of encounter with a hierarchical structure, while students scoring low on the test responded in an undifferentiated manner.

B. Scores on a relationship learning task were significantly and positively correlated with scores on Closure Speed and Closure Flexibility Tests.

C. Scores on a verbal hierarchy learning task were significantly and positively correlated with scores on Closure Flexibility and the Wonderlic Personnel Test.

D. High Siegel scoring subjects changed patterns of responding to different iconic knowledge structures and different task constraints more frequently than did low Siegel subjects.

Conclusion #7 -- Students exhibited a consistent tendency to prefer or seek to encounter first the more superordinate elements in a hierarchical knowledge structure. Further, regardless of the order in which they were presented such elements in a learning task, they tended to recall more superordinate elements than subordinate. Several alternative explanations of this finding are offered.

## Recommendations

It is recommended that additional work be done in relation to the questions which follow. Some questions tend more toward the applied or developmental while others tend more toward research or theory.

1. Producers of instructional materials already employ such iconic structures as time lines, number lines, Venn diagrams, structural formulae, taxonomic structures, flow charts, process cycles, etc. Can more of such devices be used and evaluated in instructional materials and methods?

2. In what subject areas might the iconic structuring of concepts bring order to the message designer's task of selecting and sequencing the constituent elements of messages (films, textbooks, programmed instruction, television)?

3. To what extent can the efficacy of iconic knowledge structures be increased by the innovative design of novel structures and models or the modification of known structures?

4. In what subject areas or for what kinds of objectives might iconic structures be effective in instruction, serving to aid comprehension and memory?

5. Is there a relation between the tendency to use structural aids in problem solving and the characteristics of learners and of problem situations?

6. Are certain iconic structures instrumental in facilitating transfer of learning?

7. Can iconic models and structures objectify the study of image thinking in the same way that sentences of appropriate types have objectified the study of verbal thinking (classical logic)?

8. When are the observed associations learned between iconic knowledge structures and substantive relationships: magnitude, temporal, causal, hierarchical? Can they be formally taught and at what age?

9. In what additional ways might the theoretical construct of structure serve to generate productive analogies and models of knowledge, messages, learners, and the interrelations between?

10. What kinds of iconic aids to thinking do learners generate in complex situations?

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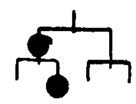
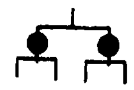
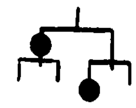
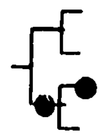
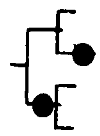
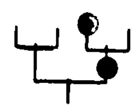
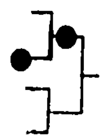
APPENDIX

Appendix A

Frequency Data and Representation of Each Structure,
Study 1A

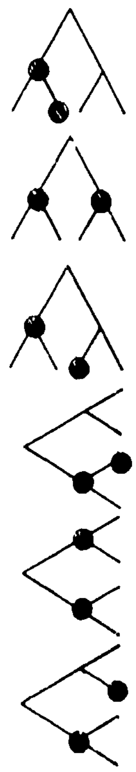
## Square Hierarchy

| | G-L | B-A | C-E | P-W | | |
|---|---|---|---|---|---|---|
| SH-1 | 15 | 14 | 13 | 15 |  | Type A |
| SH-2 | 0 | 0 | 2 | 1 |  | Type B |
| SH-3 | 14 | 8 | 1 | 1 |  | Type C |
| SH-4 | 14 | | | 15 |  | Type A |
| SH-5 | 2 | | | 1 |  | Type B |
| SH-6 | 11 | | | 3 |  | Type C |
| SH-7 | 15 | | | 15 |  | Type A |
| SH-8 | 14 | | | 14 |  | Type A |

Appendix A (Continued)

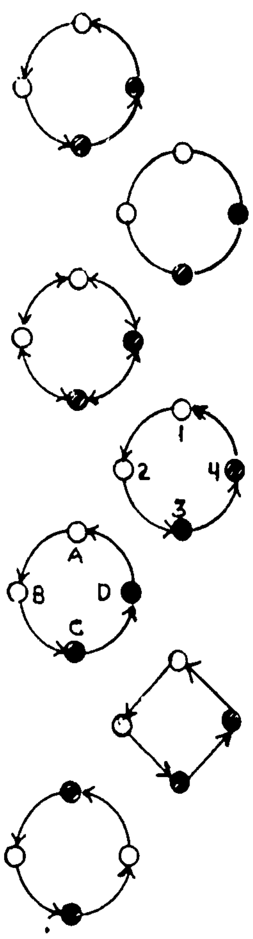
## Diagonal Hierarchy

| | G-L | B-A | C-E | P-W | |
|---|---|---|---|---|---|
| DH-1 | 14 | | | 15 | Type A |
| DH-2 | 1 | | | | Type B |
| DH-3 | 11 | | | | Type C |
| DH-4 | 13 | | | 15 | Type A |
| DH-5 | 0 | | | | Type B |
| DH-6 | 13 | | | | Type C |



## Cycle

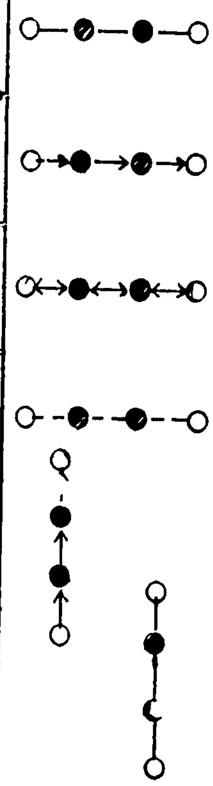
| | G-L | B-A | C-E | P-W |
|---|---|---|---|---|
| C-1 | 6 | 13 | 13 | 5 |
| C-2 | 0 | 2 | 3 | |
| C-3 | 1 | 3 | 7 | |
| C-4 | 6 | 14 | 12 | |
| C-5 | 7 | 15 | 13 | |
| C-6 | 3 | 13 | 11 | |
| C-7 | 2 | 12 | 8 | |



Appendix A (Continued)

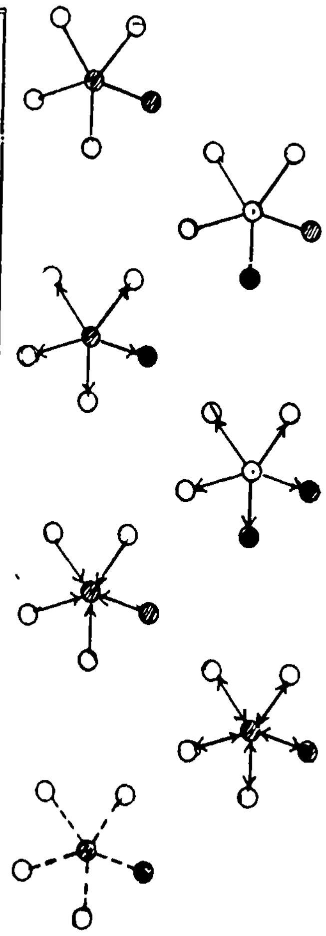
## Linear

| | G-L | B-A | C-E | P-W |
|---|---|---|---|---|
| L-1 | 2 | 1 | 3 | |
| L-2 | 7 | 14 | 13 | |
| L-3 | 0 | | 7 | |
| L-4 | 4 | | 0 | |
| L-5 | 12 | | 15 | |
| L-6 | 6 | | 2 | |



## Star

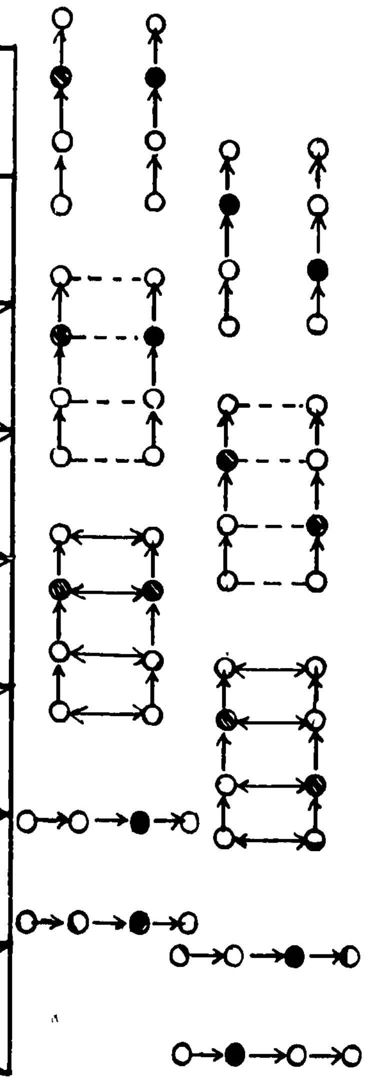
| | G-L | B-A | C-E | P-W |
|---|---|---|---|---|
| S-1 | 15 | 9 | 12 | 14 |
| S-2 | 1 | 0 | 0 | 1 |
| S-3 | 14 | | 14 | 14 |
| S-4 | 0 | | 1 | 0 |
| S-5 | | | 12 | 15 |
| S-6 | | | 13 | 12 |
| S-7 | | | 5 | 13 |



Appendix A (Continued)

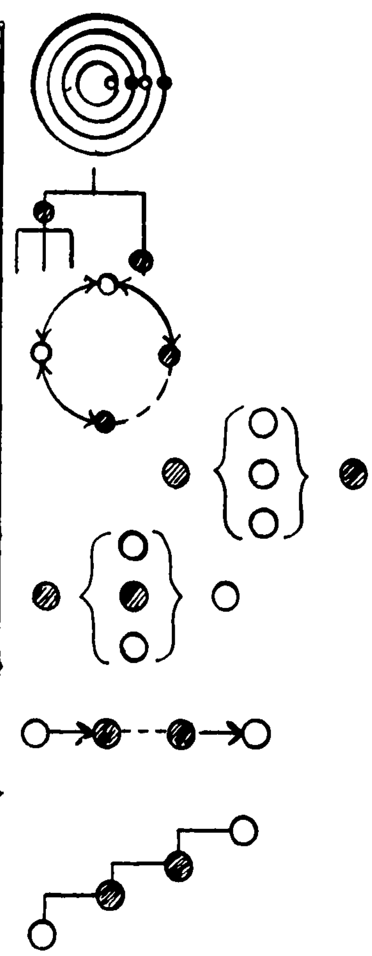
## Parallel

| | G-L | B-A | C-E | P-W |
|---|---|---|---|---|
| P-1 | 0 | 1 | 2 | 0 |
| P-2 | 13 | 7 | 1 | 1 |
| P-3 | 0 | | 1 | |
| P-4 | 10 | | 2 | |
| P-5 | 3 | | 6 | |
| P-6 | 7 | | 6 | |
| P-7 | 0 | 0 | 1 | |
| P-8 | 8 | 10 | 2 | |



## Miscelaneoops

| | G-L | B-A | C-E | P-W |
|---|---|---|---|---|
| M-1 | 12 | | | |
| M-2 | 10 | | | 4 |
| M-3 | | 2 | 4 | |
| M-4 | 0 | | 4 | 2 |
| M-5 | 11 | | 11 | 14 |
| M-6 | 7 | 11 | | |
| M-7 | 8 | | | |



## Appendix B

### Frequency Data and Representations of Each Structure, Study 2

LOR → ZEK → BAP → ? → CUL → WOK

N = 39

| | LOR | ZEK | BAP | CUL | WOK |
|---|---|---|---|---|---|
| 1st | 17 | 1 | 16 | 2 | 4 |
| 2nd | 3 | 16 | 2 | 12 | 7 |
| 3rd | 4 | 11 | 18 | 3 | 4 |
| 4th | 4 | 8 | 3 | 19 | 6 |
| 5th | 12 | 4 | 1 | 4 | 19 |

11 Bracketers
- 7 Bracketer-far bracketers
- 1 Bracketer-stringer
- 3 Bracketer-low siders

6 Extremists
- 3 Extremist-stringers
- 3 Extremist-bracketers

11 Stringers

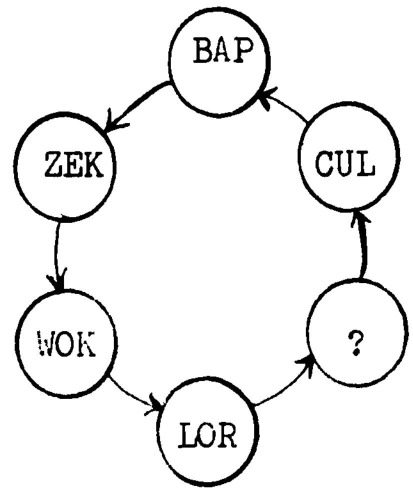
11 Odd fellows

Bracketer: 1st and 2nd choices are BAP and CUL (either order)
Bracketer-far bracketer: 3rd and 4th are ZEK and WOK
Bracketer-low sider: 3rd - ZEK, 4th - LOR, and 5th - WOK
Bracketer-stringer: 3rd - LOR, 4th - ZEK, 5th - WOK
Extremist: 1st and 2nd choices are LOR and WOK
Extremist-bracketer: 3rd and 4th are BAP and CUL
Extremist-stringer: 3rd - ZEK, 4th - BAP, 5th - CUL
Stringer: Either LOR, ZEK, BAP, CUL, WOK or WOK, CUL, BAP, ZEK, LOR
Odd fellow: none of above (example - begins with ZEK)

Appendix B (Continued)

| | CUL | BAP | ZEK | WOK | LOR |
|---|---|---|---|---|---|
| 1st | 12 | 4 | 0 | 0 | 23 |
| 2nd | 20 | 9 | 4 | 4 | 2 |
| 3rd | 2 | 10 | 13 | 12 | 2 |
| 4th | 0 | 9 | 13 | 15 | 2 |
| 5th | 5 | 7 | 9 | 8 | 10 |

N = 39



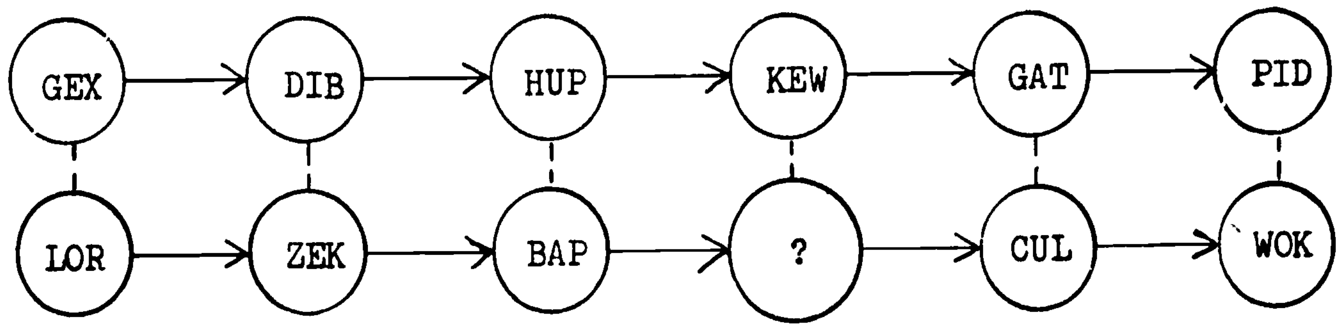

__20__ Bracketers –( __8__ Bracketer-far bracketers
( __1__ Bracketer-extremist
( __11__ Bracketer-stringers

__14__ Stringers

__5__ Odd fellows

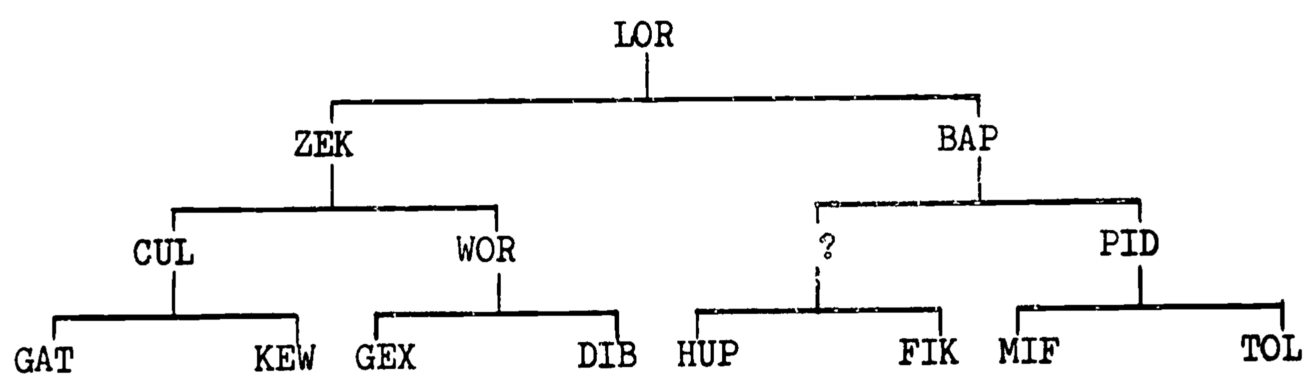
<u>Bracketer</u>: 1st and 2nd choices are LOR and CUL
<u>Bracketer-far bracketer</u>: 3rd and 4th are WOK and BAP
Bracketer-extremist: 3rd choice is ZEK
Bracketer-stringer: 3rd, 4th and 5th are BAP, ZEK, WOK or WOK, ZEK, BAP
<u>Extremist</u>: 1st choice is ZEK
<u>Stringer</u>: CUL, BAP, ZEK, WOK, LOR or reverse
<u>Odd-fellow</u>: none of above (example - beings with WOK or BAP)

Appendix B (Continued)




| | LOR | ZEK | BAP | CUL | WOK | GEX | DIB | HUP | KEW | GAT | PID |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st | 7 | | 13 | | | 5 | 2 | 1 | 12 | | |
| 2nd | 6 | 4 | 11 | 8 | 1 | 1 | 4 | 3 | 2 | | |
| 3rd | 2 | 3 | 5 | 6 | 3 | 3 | | 8 | 8 | 1 | 1 |
| 4th | 4 | 7 | 3 | 9 | 2 | 2 | | 5 | 6 | 2 | |
| 5th | 3 | 4 | 2 | 7 | 6 | | 2 | 2 | 3 | 11 | |
| 6th | 3 | 12 | 3 | | 5 | 1 | 1 | 4 | 3 | 1 | 7 |

N = 40




| | LOR | ZEK | BAP | CUL | WOR | PID | GAT | KEW | GEX | DIB | HUP | FIK | MIF | TOL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st | 23 | 1 | 6 | 1 | | 3 | 1 | | | | 5 | | | |
| 2nd | 2 | 8 | 17 | 1 | | 3 | | | | | 4 | 5 | | |
| 3rd | 3 | 3 | 11 | 1 | 1 | 10 | | 1 | | | 5 | 5 | | |
| 4th | 2 | 4 | 3 | 6 | 1 | 10 | 3 | | | | 2 | 6 | 3 | |
| 5th | 2 | 3 | | 5 | 4 | 5 | 1 | 2 | 1 | | 8 | 1 | 5 | 3 |
| 6th | 1 | 2 | | 3 | 6 | 3 | | 1 | | | 9 | 6 | 4 | 5 |
| 7th | 2 | 1 | 1 | 2 | 5 | 2 | 1 | | 1 | 2 | 5 | 7 | 6 | 5 |

N = 40

## Appendix C

### Instructions to Subjects for Free, Constrained, and Entire Tasks Studies 3A, B, and C

### INSTRUCTIONS--3rd Study

A common type of textbook illustration is one that might be called a diagram. For example, this diagram (SHOW REFINERY PICTURE) shows the operation of an oil refinery. It shows an oil well (POINTING), the distillation plant, the polymerization plant, blending tanks, and so forth. The lines show how these various elements are related.

There are numerous types of diagrams. For example (SHOW DH). Here is another (SHOW CYCLE). And another (SHOW PARALLEL). One more (SHOW LINEAR).

In such diagrams, the circles could stand for a number of things. In this diagram (SHOW STAR), the middle circle could stand for Indiana University, this circle--the School of Education, this circle--the Graduate School, this circle--the Business School, etc. Or, this middle circle could be the circulatory system, with the outer circles standing for the heart, the arteries, veins, capillaries, etc. Or, the middle circle might be Audio Visual Materials, with the outer circles standing for motion pictures, filmstrips, felt boards, slides, etc.

### FREE CONDITION

We're interested in the order in which people prefer to investigate different types of diagrams.

To illustrate, in this odd looking diagram (SHOW EXAMPLE #1) note that one element has a question mark in it. Suppose that you wanted to find out what this circle stands for, but that you had to do it by finding out what the other circles stand for--one by one. Which circle would you choose to find out about first? Logically, you might pick this one (POINTING), or this one, or perhaps this one. Suppose you picked this one, and found out that it stands for "plants." (WRITE "PLANTS" ON CELL.) That gives you some information as to what the circle with the question mark might be, but not much. What circle would you want to look at next? This one? (POINTING) OK, suppose you found that this circle stands for "animals." (WRITE "ANIMALS" ON CELL.) Now what do you think this might be? (INDICATE QUESTION MARK CIRCLE, WAIT FOR RESPONSES.) What circle would you pick next? This one? OK, this one stands for "non-living things." Now you're pretty certain that this circle must be "living things."

One more example. (SHOW EXAMPLE #2.) Again, you want to find out what the circle with the question mark stands for. Which circle would you pick first? I've given these circles names. (SHOW EXAMPLE #2 WITH NONSENSE SYLLABLES.) This one is CUL, this one BAP, this one is ZEK, and so forth. I would like you to write down on your score sheet under where it says "example" the name of the circle you would like to see first. Then, on the line labeled "second," write down the name of the circle you would like to see second, then the third, the fourth and the fifth. Do this now please. Don't leave any blanks. (WAIT FOR COMPLETION.)

Everyone done? OK, you should now have the circles listed in the order of preference in which you would like to find out about them. I should mention that there are a few minor imperfections in these drawings. For example, I see that these lines here don't quite meet; but please ignore these minor flaws. Respond to the diagrams as if they were perfectly drawn.

I have some other diagrams that I would like you to rate in this same manner. Before we do this, are there any questions about what I would like you to do?

OK, here is the first diagram. For display number 1 on your scores sheet, list the circles in the order in which you would like to find out about them. Remember you are trying to find out what the circle with the question mark stands for.

ADMINISTER NUMBERS 1-4.

CONSTRAINED CONDITION

OK, you should be ready for number 5 now. Please turn to the back of your score sheet.

Actually what we've done so far has been to get you warmed up and thinking about these diagrams. Now comes the part that we're really interested in. I'm going to show you the same four diagrams that you just rated again--one after the other in the same order, and would like you to rate them in the same way a second time. There are, of course, many different orders in which you might chose to find out about the circles. Some orders are better than others. That is, some strategies are better than others. Let's look at this example again. (SHOW EXAMPLE #1) Recall that the problem is to find out what this circle stands for (INDICATE QUESTION MARK CIRCLE). Here, it would probably be a very poor strategy to chose to see this one first, this one second, this one third, and then perhaps this one. A better strategy might be to look at this one first, and then these second and third, and so on. I don't really know what would be best for this diagram. But for the four

diagrams we have been working with, we do know what the best strategy is, and the next best strategy, and so on. A research team at MIT had a computer determine the relative efficiency of all possible orders in terms of solving for the question mark circle. By applying information theory, and a large number of actual uses of these diagrams, the computer calculated the best strategies that should be used to solve for the question mark circles. A group of Harvard graduate students were able to rate these diagrams with about 85% efficiency as compared with the ideal strategies determined by the computer. A group of Radcliffe undergraduates--all girls--did slightly better.

So with that background, I'd like you to rate these diagrams again. You might conceive of your task as follows: First, decide what circle would be the most valuable in terms of giving you information about the question mark circle, and write that down. Then decide what the next most valuable circle is, and write that down. And then the third most valuable, the fourth, and so forth. When you are through, you should have the circles listed in a strategic order, one that should allow you to predict what the question mark circle stands for as soon as possible--that is, after having seen as few of the other circles as possible. You may quite possibly have done this the first time through, or now that you have gained some familiarity with the problem, you may want to do it differently. Don't look back at how you rated the diagrams the first time. To discourage you from doing this, I've given the circles different names for this next run through. After these four, we'll have four other diagrams of a somewhat different nature. OK, try to think of the best strategy to adopt, listing the circles in the order in which they can give you information about the question mark circle. Any questions? OK, here is the first one--number five on your score sheet.

ADMINISTER NUMBERS 5-9.

## ENTIRE (WHOLE) STRUCTURE CONDITION

Now I'd like you to change your point of view somewhat. We're passing out a sheet that has four diagrams again, but this time they won't have a question mark circle. I'd like you to list the circles in the best order again, but this time in the order that you would like to see them so as to best understand the whole structure. Your objective this time is to find out what the total diagram is all about--to eventually learn what is in each of the circles in the diagram, and to do it in the most logical and efficient manner. We don't have computer data on this problem, and don't know the actual best strategies for this task, but we hope to get some indication of this from your ratings. On your sheet, write one in the circle that you would like to find out about 1st. Write 2 in the circle you would like to find out about 2nd. Does everyone understand what the problem is now? -- to list the circles in the best order if you wanted to find out about the structure as a whole. Any questions?

ADMINISTER NUMBERS 9-12.

Appendix D

**Data for Study 4**

Scores and Ranks for Standard Tests and for Tasks
Subjects by Conditions and by Interviewer

| Condition | Subject number | Sex | Inter-viewer | Siegel-Siegel | | Simi-lari-ties | | Closure speed | | Closure flex. | | Relationship learning: # correct | | Relationship learning: Time | | Card ordering: Experimenter's groups | | Card ordering: Subjects' groups | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | S | R | S | R | S | R | S | R | S | R | S | R | S | R | S | R |
| STRUCTURE SALIENT | 1 | M | A | 30 | 5½ | 16 | 13½ | 12 | 19 | 81 | 7 | 9 | 5 | 6½ | 12 | 24 | 14½ | 88 | 2 |
| | 2 | F | A | 19 | 10 | 19 | 6 | 12 | 19 | 66 | 10 | 5 | 15½ | 8½ | 18 | 24 | 14½ | 65 | 4 |
| | 3 | F | A | 30 | 5½ | 16 | 13½ | 16 | 11½ | 99 | 3 | 10 | 1½ | 7½ | 14 | 32 | 6½ | 32 | 17½ |
| | 4 | F | B | 39 | 1½ | 16 | 13½ | 23 | 1 | 69 | 8 | 10 | 1½ | 3½ | 5 | 32 | 6½ | 32 | 17½ |
| | 5 | F | B | 27 | 8 | 20 | 2 | 15 | 15 | 68 | 9 | 7 | 10 | 4 | 7 | 64 | 1½ | 48 | 10 |
| | 6 | M | A | -2 | 15½ | 14 | 20 | 18 | 6 | 62 | 12 | 2 | 19½ | 8 | 16½ | 30 | 10½ | 38 | 13½ |
| | 7 | F | A | 11 | 12 | 16 | 13½ | 16 | 11½ | 53 | 17 | 6 | 12½ | 5 | 8½ | 25 | 12½ | 49 | 7½ |
| | 8 | F | B | -2 | 15½ | 15 | 17½ | 14 | 17 | 60 | 14½ | 6 | 12½ | 14 | 20 | 18 | 17 | 50 | 6 |
| | 9 | F | B | 8 | 14 | 19 | 6 | 16 | 11½ | 32 | 20 | 8 | 8 | 5½ | 10 | 40 | 3 | 49 | 7½ |
| | 10 | F | B | 11 | 12 | 15 | 17½ | 18 | 6 | 60 | 14½ | 9 | 5 | 3 | 2½ | 25 | 12½ | 41 | 12 |
| STRUCTURE FREE | 11 | F | A | 34 | 4 | 20 | 2 | 18 | 6 | 83 | 4½ | 9 | 5 | 3½ | 5 | 0 | 19 | 256 | 1 |
| | 12 | F | A | 28 | 7 | 18 | 9 | 16 | 11½ | 82 | 6 | 5 | 15½ | 3½ | 5 | 32 | 6½ | 32 | 17½ |
| | 13 | F | B | 35 | 3 | 15 | 17½ | 19 | 3 | 114 | 2 | 9 | 5 | 3 | 2½ | 32 | 6½ | 32 | 17½ |
| | 14 | F | B | 23 | 9 | 19 | 6 | 17 | 9 | 62 | 12 | 7 | 10 | 6 | 11 | -4 | 20 | 64 | 5 |
| | 15 | M | B | 39 | 1½ | 17 | 10½ | 15 | 15 | 51 | 18 | 2 | 19½ | 7½ | 14 | 21 | 15 | 38 | 13½ |
| | 16 | M | A | -10 | 19 | 17 | 10½ | 18 | 6 | 118 | 1 | 9 | 5 | 2½ | 1 | 64 | 1½ | 48 | 10 |
| | 17 | M | A | 11 | 12 | 15 | 17½ | 20 | 2 | 83 | 4½ | 5 | 15½ | 5 | 8½ | 8 | 18 | 48 | 10 |
| | 18 | F | A | -15 | 20 | 19 | 6 | 15 | 15 | 62 | 12 | 7 | 10 | 8 | 16½ | 30 | 10½ | 72 | 3 |
| | 19 | F | B | -9 | 18 | 19 | 6 | 12 | 19 | 38 | 19 | 5 | 15½ | 7½ | 14 | 32 | 6½ | 32 | 17½ |
| | 20 | F | B | -6 | 17 | 20 | 2 | 18 | 6 | 57 | 16 | 4 | 18 | 9 | 19 | 32 | 6½ | 32 | 17½ |

S = score, R = rank

Appendix D (Continued)

## Scoring Procedure for Study 4B
## Using Experimenters' Categories

In general the subjects' groupings of the cards were examined with reference to the experimenters', Figure 13. The 16 cards, bottom row of the hierarchy ("tangible" concept), were seen as consisting of four experimenter-groupings of four cards each. Any grouping to which the subject assigned a name was compared to the four experimenter-groupings. The number of elements in a subject's grouping which matched those in the experimenters' grouping was reduced by the number which did not match. The resulting number, squared, was the score for that grouping. There follow several examples.

Example 1

Only four items in a group. These four items identical to the four in our hierarchy, same groups except that the order has been changed:

| | | | |
|---|---|---|---|
| sunflower<br>daffodil<br>oak<br>pine | or | oak<br>daffodil<br>pine<br>sunflower | 4 correct items, squared for weighting = 16 points for this grouping |

Example 2

Only two items in a group. These two items are identical to two of the four in our hierarchy and can be any of the two included in our group of four:

| | | | |
|---|---|---|---|
| beer<br>water | or | oil<br>water | 2 correct items, squared for weighting = 4 points for this grouping. |

Example 3

Groupings that result in penalties.

| | | |
|---|---|---|
| A. | beer<br>dirt | Our hierarchy groups beer as a liquid; dirt as a solid. This grouping is penalized -2 points because they are not grouped according to our hierarchy. |
| B. | trout<br>bass<br>water | Trout and bass are correctly grouped. Water doesn't belong in the same group. Therefore, the subject's score is 2 correct (trout and bass) minus 1 incorrect (water) = 1 correct, squared = 1 point. |
| C. | aluminum<br>gasoline<br>oil<br>rock<br>steel | Aluminum, rock, and steel fall in our solid category (3 correct); but gasoline and oil fall in another category (liquid) so there are 2 incorrect responses. Thus, placing items in one category that we have placed in two categories causes a penalty: 3 - 2 = 1, squared still equals 1 point. |

| | |
|---|---|
| C. aluminum<br>gasoline<br>oil<br>rock<br>steel<br>water | Three in the solid category; three in the liquid category. Therefore, score is 3 minus 3 = 0, squared still is 0. |

<u>Example 4</u> - Total score for one subject

| | |
|---|---|
| lion<br>tiger | +2 points, squared = 4 points |
| gasoline -2<br>oil<br>dirt<br>rock<br>steel +4<br>aluminum | +4 -2 = 2 points, squared = 4 points |
| water -1<br>bass<br>trout +2 | +2 - 1 = 1 point, squared = 1 point |
| sunflower<br>daffodil<br>oak<br>pine | +4, squared = 16 points |
| beer | -1 = - 1 points |

Total points = 4 + 4 + 1 + 16 - 1 = 24 points

## Scoring Procedure for Study 4B Using Subjects' Categories

In general the subjects' groupings of the cards were accepted as is, i.e., any one or more cards to which the subject assigned a label was classed as a grouping and scored as such without reference to the experimenters' preconceived category system, Figure 13.

Scoring was arrived at by a straightforward counting and squaring of the number of elements in each subject-identified group. The example which follows used the same data as in Example 4 shown in the preceding procedure.

Appendix D (Continued)

Example

| | |
|---|---|
| lion | 2 points, squared 4 points |
| tiger | |
| gasoline | 6 points, squared 36 points |
| oil | |
| dirt | |
| rock | |
| steel | |
| aluminum | |
| water | 3 points, squared 9 points |
| bass | |
| trout | |
| sunflower | 4 points, squared 16 points |
| daffodil | |
| oak | |
| pine | |
| beer | 1 point, squared 1 point |

Total 66 points

Appendix E

Study 5B Scores and Ranks, Closure Flexibility and Wonderlic Ranks

| Subject | Superordinate order Tangible | Superordinate order Word | Subordinate order Tangible | Subordinate order Word | Task Total | Task Rank | Closure Flex. Rank | Wonderlic Rank |
|---|---|---|---|---|---|---|---|---|
| 1 | 16 | | | 9 | 25 | 26.5 | 16.5 | 6 |
| 2 | 18 | | | 8 | 26 | 14.5 | 11 | 3.5 |
| 3 | 15 | | | 15 | 30 | 20.5 | 8 | 24.5 |
| 4 | 16 | | | 21 | 37 | 7.5 | 14.5 | 10 |
| 5 | 18 | | | 18 | 36 | 10 | 9 | 10 |
| 6 | 26 | | | 18 | 44 | 2 | 7 | 2 |
| 7 | 18 | | | 17 | 35 | 12 | 3 | 27.5 |
| 8* | 17 | | | 12 | 29 | 22.5 | 2 | 10 |
| 9 | 22 | | | 10 | 32 | 15.5 | 1 | 1 |
| 10 | 16 | | | 15 | 31 | 18 | 25 | 15.5 |
| 11 | 12 | | | 13 | 25 | 26.5 | 31.5 | 22.5 |
| 12 | 14 | | | 15 | 29 | 22.5 | 20.5 | 26 |
| 13 | 19 | | | 12 | 31 | 18 | 19 | 15.5 |
| 14 | 14 | | | 12 | 26 | 24.5 | 23 | 27.5 |
| 15 | 20 | | | 17 | 37 | 7.5 | 22 | 15.5 |
| 16 | 17 | | | 6 | 23 | 28 | 31.5 | 15.5 |
| 17 | 22 | | | 16 | 38 | 6 | 27 | 20 |
| 18 | | 17 | 17 | | 34 | 13.5 | 6 | 10 |
| 19 | | 21 | 20 | | 41 | 4 | 13 | 15.5 |
| 20 | | 19 | 30 | | 49 | 1 | 16.5 | 3.5 |
| 21 | | 11 | 23 | | 34 | 13.5 | 5 | 20 |
| 22 | | 13 | 19 | | 32 | 15.5 | 10 | 5 |
| 23 | | 18 | 25 | | 43 | 3 | 4 | 15.5 |
| 24 | | 13 | 23 | | 36 | 10 | 14.5 | 7 |
| 25 | | 17 | 22 | | 39 | 5 | 12 | 24.5 |
| 26 | | 20 | 16 | | 36 | 10 | 18 | 31 |
| 27 | | 5 | 14 | | 19 | 30 | 20.5 | 22.5 |
| 28 | | 8 | 8 | | 16 | 33 | 29 | 30 |
| 29 | | 8 | 11 | | 19 | 30 | 33 | 32 |
| 30 | | 12 | 19 | | 31 | 18 | 26 | 20 |
| 31 | | 12 | 18 | | 30 | 20.5 | 24 | 10 |
| 32 | | 9 | 9 | | 18 | 32 | 28 | 29 |
| 33 | | 11 | 8 | | 19 | 30 | 30 | 33 |

*Dropped randomly for ANOVA but retained for correlation.